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THE SCIENCE TEACHER

JOURNAL OF THE NATIONAL SCIENCE TEACHERS ASSOCIATION

THE SCIENCE TEACHER

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The National Science Teachers Association is a department of the National Education Association and an affiliate of the American Association for the Advancement of Science. Established in 1895 as the NEA Department of Science Instruction and later expanded as the American Council of Science Teachers, it merged with the American Science Teachers Association and reorganized in 1944 to form the present Association.

Vol. XXV, No. 6 **October 1958**

Editor's Column

We are pleased to welcome as our Guest Editor for this month, Dr. Ellsworth S. Obourn, Specialist for Science, U. S. Office of Education. Dr. Obourn has prepared the following summary of implications of the National Defense Education Act of 1958 for science teaching. He is well known for his many years of service as a science teacher, also for his work in science education in Thailand, and with the Paris Office of UNESCO. He is active in NSTA and in other science teaching associations.

RHC

Now that the National Defense Education Act of 1958 has been signed into law by President Eisenhower, it is essential that science teachers be made aware of the implications of the Bill for them. The provisions of the Act can attain their full potential only as they are understood and made to function in every school district of the Nation.

The Science Teacher carried an article on the Bill in the September issue which gave the general provisions of the Act. Several of the titles of the Bill have provisions which will serve to strengthen science teaching, and no doubt the long-range potential of the Bill lies in the inter-relation of the provisions. Since there is a limitation of space, this analysis will deal mostly with *Title III—Financial Assistance for Strengthening Science, Mathematics, and Modern Foreign Language Instruction.* Under this title, three related programs are authorized as follows:

I. A program of grants to State educational agencies for projects of local educational agencies for the acquisition of laboratory or other special equipment for science, mathematics, or modern foreign language teaching in public elementary or secondary schools or junior colleges, and for minor remodeling of laboratory or other space to be used for such equipment;

II. A program of loans to nonprofit, private elementary and secondary schools for the same types of projects; and

III. A program of grants to State educational agencies for expansion or improvement of supervisory or related services in public elementary and secondary schools and junior colleges in science, mathematics, and modern foreign language instruction, and for administration of the program set forth in I, above.

The appropriations to carry out these programs are: $70 million for each of the four fiscal years 1959, 1960, 1961, 1962, is authorized to be appropriated for programs I and II. Twelve per cent of the amounts appropriated for any such year are reserved for loans under program II and the remainder is available for program I.

Annually $5 million for each of these four years is authorized to be appropriated for program III grants.

(Continued on next page)

THE SCIENCE TEACHER

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An Analysis of the Programs

Program I—Grants to States for instructional equipment for science, mathematics, and modern foreign language.

Allotment. Up to 2 per cent of the aggregate amount appropriated for programs I and II for any year is allotted among Alaska, Hawaii, Puerto Rico, the Canal Zone, Guam, and the Virgin Islands according to their respective needs. The remainder (exclusive of the 12 per cent reserved for loans under program II) is allotted to the 48 States and the District of Columbia on the basis of a statutory formula which takes into account school-age populations (5 to 17, inclusive) of these States and their incomes per school-age child; these allotments remain available for payment for projects until the end of the fiscal year following the year for which the allotment is made.

Matching. States or local school systems must match Federal funds on a dollar-for-dollar basis.

State plans. Any State desiring to receive payments under this program must submit to the U. S. Commissioner of Education, through its State educational agency, a State plan which (A) sets forth a program under which Federal funds will be expended solely for projects approved by the State agency for acquisition of laboratory or other special equipment (including audio-visual materials and equipment and printed materials, but excluding text books) suitable for use in providing education in science, mathematics, and modern foreign languages in public elementary or secondary schools or junior colleges, and for minor remodeling of laboratory or other space used for such equipment; (B) sets forth principles for determining the priority of such projects in the State; (C) provides an opportunity for a hearing before the State agency to any applicant for a project; (D) provides for State standards for laboratory or other special equipment acquired with these Federal funds; (E) sets forth a program under which funds paid to the State under program 3 will be expended solely for the permitted purposes (see below); and (F) provides for necessary fiscal procedures and reports.

Program II—Loans to nonprofit, private schools.

Allotment. The 12 per cent of each year's appropriation for programs I and II, which is reserved for program II, will be allotted among the States on the basis of the number of persons enrolled in private, nonprofit elementary and secondary schools in the States.

Loan conditions. Loans are made by the Commissioner to private, nonprofit elementary or secondary schools for the same purposes for which grants to States under program I can be used. The schools must make applications containing information deemed necessary by the Commissioner, the loan agreements will be subject to conditions necessary to protect the financial interest of the United States, and the loans will bear interest at a rate equal to ¼ of 1 per cent plus a percentage equal to the current average yield on all outstanding marketable obligations of the United States as of the last day of the preceding month, and be repayable in not more than ten years.

Program III—Grants to States for State supervisory services

Allotment. Up to 2 per cent of the amount appropriated for this program for any year is allotted among Alaska, Hawaii, Puerto Rico, the Canal Zone, Guam, and the Virgin Islands, according to their respective needs. The remainder is allotted to the 48 States and the District of Columbia on the basis of their school-age populations, but the allotment to any such State cannot be less than $20,000.

Matching. The States must match these Federal grants on a dollar-for-dollar basis for each fiscal year after the first fiscal year.

Use of Federal funds. These grants are available solely for (A) expansion or improvement of supervisory or related services in public elementary or secondary schools in the fields of science, mathematics, engineering, and foreign language, and (B) the administration of the State plan for this program and program I.

State plan. In order to qualify for these grants, the State must have submitted a State plan meeting the requirements for program I above.

Based on the above analysis, the following things have promise for the long-range improvement of science teaching in the public schools of the Nation:

1. *Securing a strong supervisory or consultant staff both at State and local levels.* It has long been recognized that a well supervised program in any instructional field is likely to insure a better program. Science, along with other academic areas, has been weak in such consultant personnel both at state and local levels. Currently, only nine States have supervisors of science. Four of these have been appointed within the past year and at least two of them also have responsibility for mathematics.

2. *Improving facilities for science teaching through projects of minor remodeling.* It is generally conceded that science facilities over the country are poor. The provisions of this Bill will make it possible for schools to expand and modernize their present facilities, and to secure funds for instructional equipment in new buildings.

3. *Improving the equipment for science teaching.* If science teaching is to really be improved, it is necessary for the laboratory to play a much more important role. It is the experimental approach that makes science unique from other subjects in the curriculum. This Bill provides funds which may be used by schools to build up both the individual experiment and the teacher-demonstration phases of science teaching.

4. *Securing more teaching aids.* This provision includes teaching aids and equipment and printed material other than textbooks. It will enable schools to modernize their visual aids equipment and to secure such things as models, charts, pictures, and other important supplementary aids. This could go a long way in improving the teaching of science in this country.

The task of implementing this legislation is one of great magnitude. Infinite details must be considered, legal interpretations of the provisions must be made, and administrative and professional programs must be planned and staffed. These are now in the process of being developed. Planning is going forward in close cooperation with State education agencies and with consultants from several areas, including those of science, mathematics, and foreign language. When the program plans, cooperatively developed with the States, have been finalized, each Chief State School Officer will provide information to local school authorities.

ELLSWORTH S. OBOURN

Readers' Column

May I commend you on your recent and excellent publication, *It's Time for Better Elementary School Science.* As an indication of our approval and active interest, I enclose a check for $12 for fifteen copies of the report.

STURTEVANT HOBBS
Assistant to the President
D. C. Heath and Company
Boston, Massachusetts

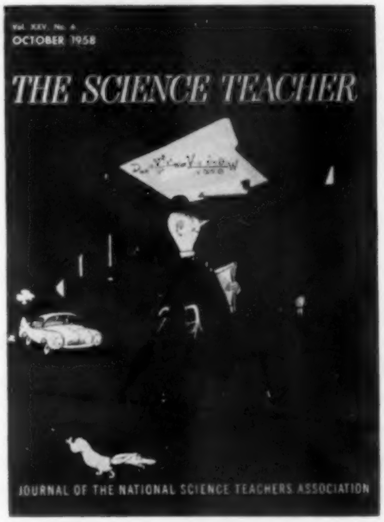
May I have 100 of the Science Certificates of Achievement. I plan to give a Science Achievement Test to the County Eighth Grade Class which will number about 700 this fall and I would like to present the certificates to the top 10 per cent in the Class. Thank you.

ALEX M. JONES
County Superintendent
Lancaster, Wisconin

Enclosed is remittance for a sustaining membership for another year. I have enjoyed the magazine and have found great use of many of the packet materials. The service is well worth the price.

D. C. YOCOM
2219 Superior
Middletown, Ohio

THIS MONTH'S COVER . . . re-introduces a good friend of high school science teachers, Dr. Richard M. ("Dick") Sutton. The cover cartoon, done by Robert Pilgrim of Silver Spring, Maryland, was inspired as a result of Dick's lead article in this issue of *TST,* "The Jay-Walker's Equation." It is another example of his high ability to stimulate student interest in physics through the use of dramatization, showmanship, and the novel or familiar daily experience. Since writing this article, Dr. Sutton has accepted appointment to a new position as Professor of Physics and Director of Relations with Secondary Schools at California Institute of Technology, Pasadena.



The Jay-Walker's Equation

By RICHARD M. SUTTON

Case Institute of Technology, Cleveland, Ohio

THE FOLLOWING CONTRIBUTION to the mathematics of dangerous living is submitted for inclusion among the growing literature of survival. Unfortunately, it may be too late to save the cause of the vanishing pedestrian who, by being on his feet while crossing a street, is automatically classified as a member of the species *Jay-Walker,* a bird avidly hunted by the motorist and now nearing extinction. Even if the pedestrian crosses in the legal game preserves, marked on the street by white lines, he is still in peril from heel-clipping motorists. Will Rogers used to say about traffic, even in the halcyon days of 1930, "If you get hit between the lines, it doesn't count!"

The problem will be approached from different levels of sophistication, but first let us look at one of the worst levels. The general problem of street crossing, the random walk in the middle of the block in the midst of two-way traffic, is best treated by the statistical methods of the kinetic theory of gases. It is not unlike the study of viscosity and the transfer of momentum between the layers of a gas. In this case, without benefit of white lines and traffic signals, the pedestrian's progress strongly resembles the Brownian motion of a supramolecular particle. The mean free path between collisions or between abrupt changes of course is a function of gas density (number of cars per cubic mile) and temperature (their root-mean-square velocity). The chance of crossing any street safely is an exponentially decreasing function of the width of the street. Perhaps the concept of "half-life," so useful in the study of radioactivity, may have significant bearing on this problem also.

The random walk in traffic presents too many variables, complicated by psychological factors from which molecules are supposedly free. As we cannot treat it by elementary means, let us follow the usual practice in the face of mathematical complexities and adopt a simplified version of the problem, thus reducing it to more tractable form. It is hoped that the problem may still show interesting features and offer progressive levels of difficulty for the student of pedestrianism and dead reckoning.

The Model and the Problem

Assume a multi-lane, one-way highway on which cars descend toward a crosswalk CE in a solid wave AB at speed V, small compared with the velocity of light. Let a pedestrian start from C and walk with speed v. Let the width of the street be W. Assume further that the pedestrian walks in a straight path across the highway at some angle Θ, but without benefit of controlling lights.

What *minimum* distance $D=BC$ from his starting point should be clear of approaching automobiles so that he may cross safely?

Fortunately, although this is a life-and-death problem, it is subject to a simple, conservative and safe solution.

1. Let the pedestrian cross the street at right angles along CE. Then his time of crossing must be not less than the time for the motorist in the far lane to arrive. Thus $vt=W$, and $Vt=D$. It is apparent that the ratio of minimum distance D to street width W, namely D/W, must equal the ratio of velocities, $\frac{V}{v}$. What could be simpler?

2. But the experienced jay-walker sees that this is too elementary a solution. Surely, he reasons, if I go across at some angle Θ, I will gain a little time and I can shave D a bit. Now, he may be "dead" right, but he has immediately complicated the problem. What relation exists between D and Θ? How can we find an absolute minimum value of D (and the measure of the corresponding angle Θ) for any given values of v, V, and W? Let us see how to work the problem (A) graphically, by the simple tools of geometry; (B) graphically, by use of algebra and trigonometry; (C) "rigorously," by the use of differential calculus; (D) by a relativity transformation of the problem into a "stationary motorist and moving street" variant.

(A) If the jay-walker crosses traffic "on the bias" from C to F, he necessarily goes a longer distance d while the approaching automobiles go a total distance $D+x$. As before, we see that $\frac{D+x}{d}=\frac{V}{v}$. Therefore, we need only to draw two parallel lines to represent W and assume a given constant ratio of velocities V/v. Then for each d at some arbitrarily chosen path angle Θ there is a line $AF=D+x=\frac{V}{v}d$ laid off to the left from his point of arrival F. By allowing Θ to increase in steps of 5° or 10°, the diligent geometer will soon discover that A moves toward E for a time, thus making $AE=D$ smaller and smaller as desired. Finally, however, as Θ is still further increased, A begins to recede to the right. The pedestrian has therefore exceeded the optimum angle and the far-lane car is likely to clip him unless he throws away our mathematical model and makes a last second leap for the curbing!

(B) For those who know trigonometry, let us implement the diagram of Figure 1. We are interested in making D/W as small as possible.

Now $AF=D+x=Vt$, and $CF=d=vt$.

But as $d=W \sec \Theta$ and $x=W \tan \Theta$ we have,

$$\frac{D}{W}=\frac{V}{v}\sec\theta-\tan\theta \qquad \text{Eq. (1)}$$

This is the basic Jay-Walker's Equation. Now, as we do not know D or Θ we can nevertheless examine the relation between them by making a table of values of D/W for any given ratio V/v as we let Θ take on successive values. If we graph the values of D/W as ordinate, as given by the numerically determined values of the right side of Equation (1), against the corresponding values of Θ, we obtain a curve such as Figure 2 (where a modest ratio $\frac{V}{v}=3$ has been assumed).

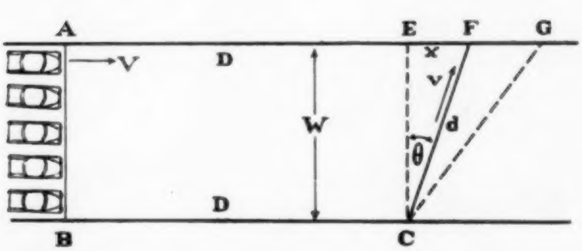


FIGURE 1. Pedestrian follows path CF to make D minimum.

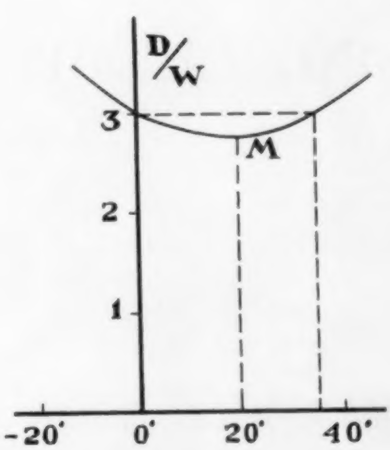


FIGURE 2. The Calculating Jay-Walker finds Angle for Minimum D/W when V/v = 3.

This graph is instructive: it shows a *minimum* value for $D/W \doteq 2.8$ when Θ is about 20°. Further, it shows that negative values of Θ (for arrival to the left of E) require bigger values of D than the straight-across path; for, as learned in the most elementary lesson in jay-walking, if you slant *toward* the approaching cars, you don't have so much time to cross. Finally, it shows that the jay-walker who takes an angle of nearly 37° in this case gets across with equal safety along the path CG as the more conservative street-crosser who goes straight across on the path CE, if both start at the same instant and walk at the same rate. If the subsequent aim is to continue in the direction G, the astute jay-walker gains a substantial advantage.

(C) As Equation (1) has two unknowns, we need a second equation to find the minimum D and its corresponding Θ. The graph of Equation (1), as presented in Figure 2, shows a dip having a minimum at the point M. Here the slope of the curve is zero. A second equation is obtained by differentiating Equation (1) with respect to Θ and setting the derivative equal to zero. This gives immediately:

$$\frac{d(D/W)}{d\theta} = \frac{V}{v}\tan\theta\sec\theta - \sec^2\theta = 0 \qquad \text{Eq. (2)}$$

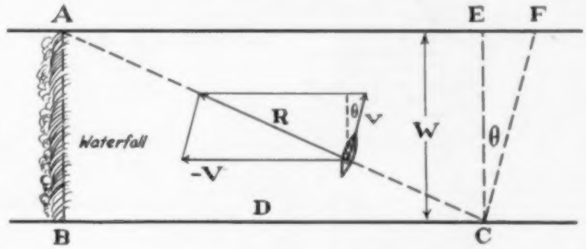
Equation (2) may be solved for Θ, giving $\sin\Theta = \frac{v}{V}$. This result is so disarmingly simple, it seems as if it should have been either inituitive or "immediately obvious," but the writer has not yet been able to comprehend it so. If this value of $\sin\Theta$ is inserted in Equation (1), it leads by appropriate trigonometric solution to the value of D_{min} given by

$$D_{min} = \frac{V^2 - v^2}{v^2}\,W = \frac{V - v\sin\theta}{v\cos\theta}\,W. \qquad \text{Eq. (3)}$$

(D) In order to take care of the motorist who "sees the pedestrian coming toward him at a dangerous rate," let us examine the relativity transformation of the motion involved. We could, for example, let the motorists line up at a red light while the pedestrian walks across a *moving highway* with speed v relative to the highway as the highway approaches the standing cars relentlessly with velocity $-V$. The same solution will prevail!

3. But the imaginative student may recognize this as another problem which he could state dramatically, as follows:

FIGURE 3. Canoeist points canoe in direction parallel to CF but makes progress along path CA.



"A canoeist can paddle at speed v with respect to the water. He launches his canoe in a stream that moves with uniform speed V measured with respect to the bank. How far upstream (or at what minimum distance) above a waterfall must he start across the stream, of width W, if he is to reach the opposite side safely? In what direction Θ with respect to the shortest line across the stream should he paddle his canoe?"

Here a vector diagram of velocities helps to visualize the situation (Figure 3) since the canoe has a velocity R relative to the bank which is the vector sum of V and v. The times of crossing to the opposite bank and of arriving at the brink of the waterful are the same, namely, which leads, as before, to Equation (1), and to the same kind of solutions for D and Θ.

$$t = \frac{W}{v\cos\theta} = \frac{D_{min}}{V - v\sin\theta} \qquad \text{(Eq. 4)}$$

4. Finally, for those who prefer their mathematics pure and who exhibit disdain for any problem until it has had all the life distilled out of it, let us see what this Jay-Walker or Canoeist problem become when stated formally:

Given a quadrilateral ABCF, (Figure 1). Angles BAF and ABC are right angles. Side AB is fixed in length and is given. Sides AF, CF and BC are not fixed in length but the ratio AF/FC is fixed and given. Find the value of Θ which makes the ratio AF/AB a minimum.

For me, a little excitement in a problem is a pleasant ingredient. Only after I have seen my pet Jay-Walker safely across the highway, or my hardy Canoeist saved from the brink of his threatening waterfall, can I begin to pursue further the properties of this flexible quadrilateral which I have been teased into considering by my experiences in crossing 4-lane traffic on East Boulevard below the Case Institute campus.

Bacteria That Make Life Possible

By AUDREY E. PRESSLER

Frederick High School, Maryland

This report was an entry in the 1957-58 STAR (Science Teacher Achievement Recognition) awards program.

PEOPLE get excited over many things: "sputniks" versus "explorers," chalk and talk teaching versus problem solving methods, and basic research versus non-research. Homo sapiens take many things for granted including nitrogen-fixing bacteria.

Recently it was stated that all animals, man and monkey alike, evolved from slimy brown seaweed. Does it matter whether man is a plant or animal? The important fact is that men and plants are interdependent. Therefore, why not play up this symbiotic relationship of the nitrogen-fixing bacteria and leguminous plants?

Too many biology teachers share with their students the nitrogen cycle as a circle drawn on the board, decorated end to end with words or pictures. Why not expose the students to self-discovery? Let the students discover that some nodules are red, indicating the presence of a plant-produced hemoglobin; that nitrogen-fixing bacteria grow well on an asparagus culture medium.

Do your students know that they need nitrogen in order to survive; that the air is four-fifths nitrogen; that man cannot use this nitrogen; that the atmospheric nitrogen must be changed into nitrates before it can be used, and thus man's dependence upon plants-nitrogen fixing bacteria?

Nitrogen-fixing bacteria are different in several aspects. There are many different kinds, each of which has the ability to thrive only in the roots of certain members of the pea family. These bacteria require a source of energy which they obtain from the green plants through roots. Nitrogen-fixing bacteria are able to utilize atmospheric nitrogen to make their own protoplasm, a feat very few organisms can perform. Furthermore, the bacteria can do this only when they are residing in the cells of the nodules.

Most legumes, or plants of the pea family, are also special in that they have the ability to harbor the nodule-forming bacteria to provide them with an energy source and to utilize the complex nitrogen containing compounds synthesized by the bacteria.

In order to help your students discover facts about nitrogen-fixing bacteria, let them set up an hypothesis, such as: Do legumes profit or suffer because of nitrogen-fixing bacteria?

In the field, have the students observe, the stem and leaves, of a sickly and a healthy clover plant. Direct them to make note of any differences as well as any environmental factors which might have influenced their growth. Then direct your students to organize and carry out the following procedures.

Dig and carefully remove both plants from the soil. Observe the root structures. Record data. Take the roots back to the laboratory. In the laboratory place the plants in a beaker of water; observe and then record any new data about the roots, especially any lump or swelling. If there is a lump, remove it from the root with a razor blade in such a way that a small portion of the root remains attached. Wash the lump or nodule. What color is it? Soak the lump in a 95 per cent alcohol solution in a Petri-dish for about one minute. Place the nodule in a Petri-dish containing a 1-1000 $HgCl_2$ solution for about five minutes.

Rinse the nodules in sterile water in a test tube. Clean a slide and sterilize by flaming. Place the nodule on the slide and crush with sterile forceps. You may add a drop of sterile water on the slide. Prepare two streak cultures on asparagus extract mannitol agar.

10 g	mannitol
0.5 g	dipotassium phosphate
0.2 g	magnesium sulphate
0.1 g	sodium chloride
100 ml	asparagus extract
15 g	agar
900 ml	distilled water

Macerate the contents of a 10 oz can of commercial asparagus with 400 ml of distilled water. Heat to 80° C for ten minutes. Filter through a pad of cheese cloth and cotton. Make the volume to 1000 ml.

Incubate the two cultures at room temperature for about seventy-two hours.

Add a loopful of water to the suspension remaining on the slide, spread it over the slide, and allow it to dry. Now heat gently over an alcohol lamp,

just passing the slide over the heat four or five times. Cool and then dip in water. Let excess water drain off. While still damp apply a drop of prepared aqueous solution of methylene blue. Heat gently for half a minute, drain off excess dye, and gently rinse two times in water. Put on a cover slide and observe with high power, or let dry and observe under oil immersion. Make a sketch of the bacteria and save it for comparison with bacteria grown in culture.

Now that your students are familiar with nitrogen-fixing bacteria, direct them to plan some experiments to determine their usefulness to man. For example, provide the group with some pea seeds, Clorox, pots, sand, and known nitrogen-fixing bacteria. Have the students sterilize the sand by heating in an oven at 250°F for about ten hours. Sterilize all the seeds in Clorox.

In one pot plant some seeds, in another plant seeds dusted with nitrogen-fixing bacteria, in the third plant seeds with the bacteria added to the sand. In pot four add the bacteria to both sand and seeds, and then plant seeds. Put these aside to grow for about six weeks. Cover sand with aluminum foil. Water through tubes in pots. Cap tubes with foil. Water should be boiled, cooled, and then stored in a stoppered flask. At the end of the six-week period record data about the plants. The students should set up their own standards for judging the plants and the effectiveness of nitrogen-fixing bacteria.

Summarize: Do legumes profit or suffer because of nitrogen-fixing bacteria?

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ENDING *Twelve Months*

AT THE EDGE OF SPACE

This article was prepared especially for *The Science Teacher* by the IGY Committee staff of the National Academy of Sciences, Washington, D. C.

THE 18-month IGY study of the earth and its environment has now reached the two-thirds mark. Data never before collected are being analyzed and evaluated in the light of related known phenomena. With additional observations and measurements gathered from the outer edge of space, man will find new problems and questions, but will also be able to derive new techniques and answers to solve unknown secrets of earth and outer space. Observations and experiments will be continued for several months. The task which follows to evaluate the raw data collected may take a long period of intensive research to relate it to the many scientific disciplines.

Currently, however, a brief summary is given of the findings by scientists from all over the world probing the earth's atmosphere. A final report will be given in the December issue.

Sun-Earth Relationships, Five Disciplines

1. Solar Activity: The period 1957-58 was selected for the IGY to coincide with an expected maximum in the 11-year cycle of solar activity. Our nearest star has not been a disappointment. In fact, the Zurich Observatory, which is the international clearing house for sunspot statistics, reports that 1957 had the highest yearly mean in relative sunspot numbers since 1778.

During the first twelve months of IGY, 14 Special World Intervals were declared by the IGY World Warning Center, which the National Bureau of Standards operates at Ft. Belvoir, Virginia. In these 24-hour periods, observers around the world stepped up their data-gathering in an effort to gain better understanding of the solar eruption mechanism and its varied terrestrial effects.

With a new instrument known as the K-coronameter or coronagraph, successful observations of previously unobserved details of the sun have been made. This device measures the brightness of light scattered by free electrons in the K-corona of the sun, permitting a study of the variation in depth of layers of the corona. (The K-corona, or "white" corona, emits about 99 per cent of the total light of the sun's corona.) [On October 12, 1958, solar scientists using a coronagraph will be stationed in the Mid-Pacific to observe an eclipse of the sun.]

Scientists at Mount Wilson Observatory have found that magnetic fields at the sun's surface may be as much as 8000 times as high as the earth's field at the equator. They note variations in polarity and intensity that seem to be closely related to various sun-earth phenomena.

2. Geomagnetism: Great electric currents, of several hundred thousand amperes, are believed to circle the earth at the geomagnetic equator and

NATIONAL ACADEMY OF SCIENCES, IGY PHOTO

Coronagraph, a specially designed telescope that photographs solar disturbances and prominences at sun's edge.

the magnetic poles. During the IGY, tentative confirmation has been reported of the existence of the equatorial "electrojet." The electrojet is thought to be the equatorial current narrowed down into a "neck" of limited horizontal dimensions, with a resulting concentration of current.

3. Aurora and Airglow: Auroras result from the interaction between electrically-charged particles hurled from the sun and particles of the earth's upper atmosphere. Auroral studies give us knowledge of the nature of the earth's atmosphere and magnetic field as well as of the solar particles.

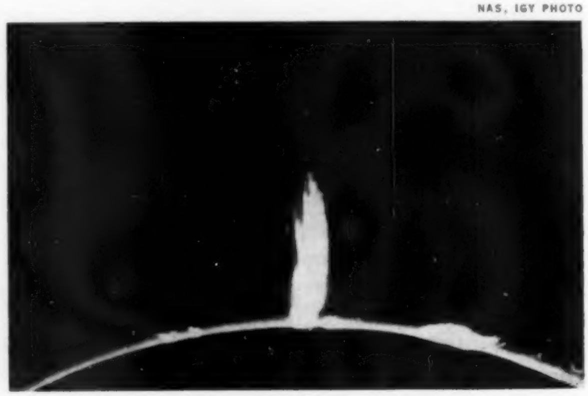
The auroral display of February 10-11, 1958, was the most carefully observed and recorded aurora in history. More than 2000 reports on it were received by the US-IGY Auroral Data Center at Cornell University. It was seen as far south as Cuba, and over an east-west range of at least 6000 miles. This aurora was of the rare red variety which generally extends to very high altitudes; its red glow ranged upward from 150 to 600 miles, although green arcs were seen at the usual 60-mile level. It was acompanied by strong magnetic and unusual earth-current effects. As a result of these, the potential on the transatlantic telephone cable from Newfoundland to Scotland reached a miximum of 2650 volts at the western end on the evening of February 10. Strong bursts of X-rays, probably the result of high-speed electrons bombarding the atmosphere, were observed on cosmic-ray balloon flights from Minneapolis. Spectra taken in Alaska showed unusually strong development of rare emission lines.

The bombardment of the atmosphere by charged particles from the sun, which causes visible auroras, also affects radio transmission. IGY studies have shown that the auroral ionization responsible for radar reflections may be formed at heights considerably greater than the 60-mile lower limit of the visual aurora. Monitoring of radio-frequency cosmic noise in Alaska indicates the existence of an auroral absorption of this cosmic noise at stations located successively south geomagnetically from College, Alaska. In addition, rocket experiments at Fort Churchill, Canada, revealed that electrons rather than ions are the primary source of auroral light.

The airglow is a strange, subvisual, nocturnal glow resulting from emissions of the oxygen and hydroxyl (OH) radicals in the upper atmosphere. It supplies more light to the sky than the stars on a moonless night. Originally, it had been thought of as a motionless glow in the sky. Actually, charting of the night airglow during IGY has shown that it is quite complex, with dramatic temporal and spatial variations. For example, separate and distinct "blobs" seem to wander through the sky at an apparent velocity of 150 miles an hour. Another finding, made by a station in Colorado, is that the airglow is brighter to the north in summer and winter, but brighter to the south in spring and autumn. The significance of these variations is not yet understood, and requires further investigation.

A giant surge prominence photographed with the Climax coronagraph of High Altitude Observatory, Colorado, while rising from surface of the sun at a speed of several hundred miles/second.

NAS, IGY PHOTO

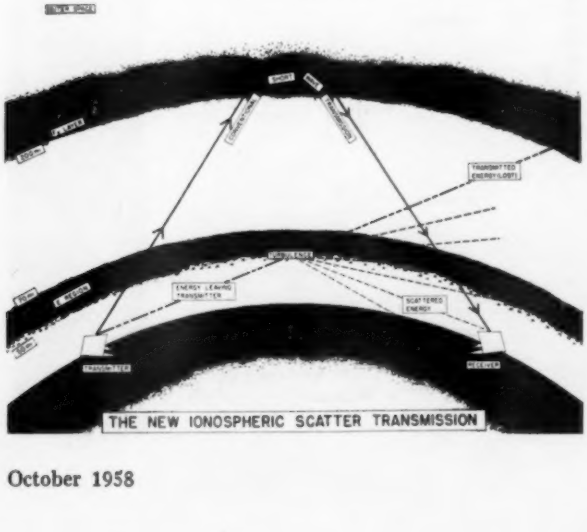


4. Ionospheric Physics: The source of ionized layers in the earth's upper atmosphere is to be found largely in solar radiation. Naturally, then, observations made of the ionosphere during the sunless Antarctic winter would be of particular interest. Surprisingly enough, first year's results from the Antarctic show that although ionization reaches a saturation point during the long summer day, the upper ionized layer (F-layer) persists even during the dark polar winter. Furthermore, although the sun remains constantly below the horizon at the South Pole in winter, there is a significant 24-hour variation in ionization. The source of this ionization and the manner in which it is maintained are subjects which require further study.

Information on the electrical composition of the lower ionosphere is of great importance in studies of the effect of solar radiation on the earth's upper atmosphere. For the first time, rocket studies in the Arctic have established that nitric oxide is the predominant positive ion in the E or middle region of the Arctic ionosphere; atomic oxygen predominant in the F, or upper region. This information is of interest in improving our understanding of the ionosphere and its efficient use in long-range radio transmissions. Rocket experiments have also shown that polar communications blackouts are caused mostly by high absorption of radio waves in the D, or lowest region of the ionosphere, at altitudes of 35-45 miles.

Various types of "scatter" effects that the ionosphere exerts on radio waves are also being studied in the IGY program. New information has been obtained on large-scale, traveling disturbances in the F-region. These disturbances appear to be a kind of gigantic wave motion. They have been traced for as far as 2000 miles and may be 2000 miles across. New data have also been gathered on the role of tilts or horizontal gradients in the ionosphere in propagating radio signals over great distances, frequently in excess of 6000 miles.

NATL BUREAU OF STANDARDS, BOULDER, COLORADO



THE NEW IONOSPHERIC SCATTER TRANSMISSION

A whole new technique for studying the ionosphere has been opened up by the beacon radio transmitters carried in IGY earth satellites. These make available for the first time a radio source well above the ionospheric layers. One puzzling early result is the discovery of radio signals apparently coming from a point on the opposite side of the world from the actual satellite. This antipodal "ghost satellite" effect has not yet been explained, but studies are still in progress.

5. Cosmic Rays: Cosmic rays are extremely high-energy, electrically-charged particles originating in our galaxy and continually bombarding the earth. Using a variety of techniques at mountain stations, in balloons, and in aircraft, U. S. scientists have found that the stream of cosmic-ray particles arriving at the earth has drastically changed in the past few years. As of early 1958, during a period of maximum solar activity, total cosmic-ray intensity above the bulk of the earth's atmospheric mass was only half that present in 1954, when solar activity was at a minimum. This raises the interesting question of whether the clouds of gas thrown off by the sun in its eruptions have magnetic fields which trap cosmic rays outside the solar system.

Upper Atmosphere Studies

Until recently, investigators have been able to study the upper levels of the atmosphere only indirectly. For example, the behavior of radio waves has taught scientists something of the electrical and magnetic properties, motions, and density of the upper atmosphere; the spectroscope has provided some information on its composition; observation of persistent meteor trails and unusually high cloud formations has revealed the existence of high-speed upper-air winds. Now, however, with the development of high-altitude research rockets during the past decade, and with the new artificial earth satellites, science has extended its reach beyond the screening effects of the dense lower atmosphere. With these new tools direct measurements can now be made of extraterrestrial particles and radiations before they are absorbed, reflected, or modified by the atmosphere. Temperature, pressure, density, and composition of various levels of the atmosphere can also now be measured directly.

Rockets and satellites share the ability to carry scientific instruments to high altitudes. Satellites, however, have the added advantage of enabling measurements to be taken over wide portions of the globe for extended periods of time. Moreover, the great speed of a satellite permits measurements that are almost synoptic in nature. In addition, satellites make possible a unique class of experiments arising from studies of the satellites when in orbit.

Satellites: A region of intense radiation has been discovered and investigated by the Explorer satellites. It begins about 600 miles out from earth and extends at least to the maximum altitudes reached by these satellites, about 1800 miles.

This phenomenon was noted by Dr. James A. Van Allen and his associates at the State University of Iowa when the Geiger tubes carried by Explorer I and III at times showed zero counting rates. Laboratory tests confirmed that this was caused not by absence of radiation, but by radiation of such intensity that it saturated the counting equipment.

In view of these findings, new equipment of greater capacity was designed and sent aloft in Explorer IV. Preliminary readings of the data

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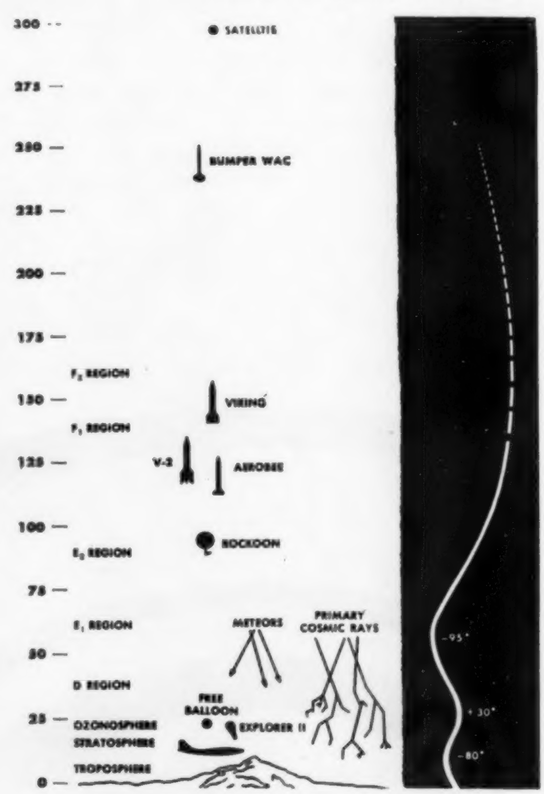


radioed back by this satellite indicate that the instruments are registering direct hits by a great many high-energy charged particles, probably electrons. It appears also that a substantial percentage of these particles penetrate the lead shielding placed around one of the Geiger tubes in Explorer IV. This suggests that additional inquiry must be directed to the problem of radiation protection for the first humans who venture into space.

Other implications seen by Van Allen are: (1) to penetrate so close to earth through the magnetic field, the particles must be associated with clouds of electrically charged matter in space (plasmas) which seriously perturb the magnetic field at a distance of about an earth radius; (2) this radiation may contribute significantly, if not dominantly, to the heating of the high atmosphere.

The density of the atmosphere at high altitudes has been computed by Smithsonian Astrophysical Observatory and Naval Research Laboratory scientists from visual and photographic studies of satellite orbits, and has been found to be as much as 15 times greater than previously estimated. Even so, on the basis of these computations, a cubic mile of air at an altitude of 230 miles would weigh only about two ounces; at sea level its weight would be perhaps 2 billion times as much.

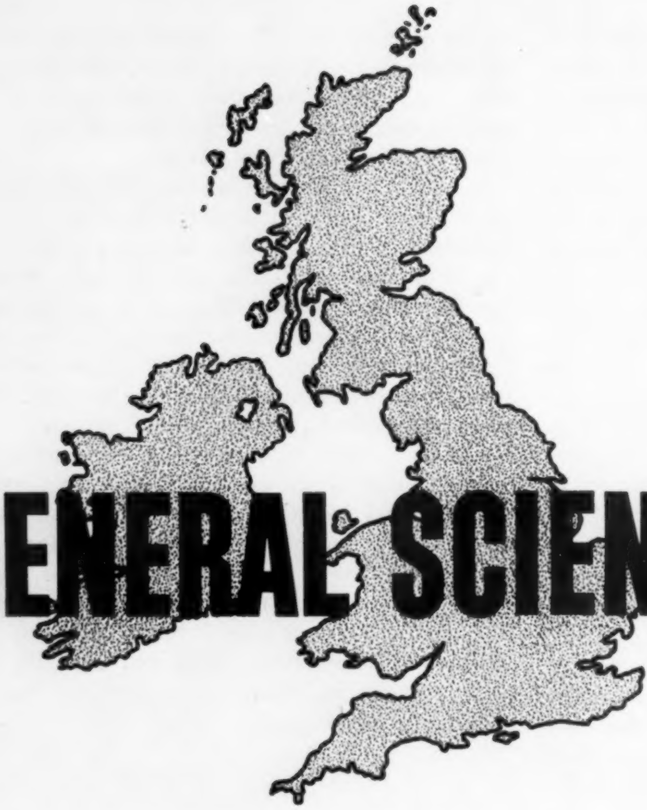
Meteor Bombardments

Impacts of micrometeorites have been relatively insignificant, the Air Force Cambridge Research Center reports, although there is speculation that a meteor swarm composed of debris from the famed Halley's Comet may have damaged the transmitters of Explorer III in May. It had been feared that erosion of the skins of satellites or space vehicles by these minute particles might be greater.

Temperatures in the interiors of the Explorer I and II satellites have been kept within a range that permits the instruments to function satisfactorily, according to scientists of California Institute of Technology's Jet Propulsion Laboratory. This is accomplished by applying reflective material to portions of the external surface of the satellites. The material reflects and re-radiates heat from both the sun and the earth. Of special significance is the fact that the temperatures achieved were within the range of human survival.

ROCKETS: US-IGY scientists explored the upper air with 116 rockets during the first 12 months of IGY. Of these, 41 were launched at Fort Churchill, Canada, a US-Canadian rocket installation especially set up for the IGY; 54 were lifted beyond the denser part of the atmosphere by balloons from shipboard in the Antarctic, Pacific, and Arctic, and then launched ("rockoon" technique); 15 were sent up from San Nicolas Island, California, and 6 from White Sands, New Mexico.

In the Arctic, rocket soundings are being made in an effort to provide a better understanding of the dynamic processes of the atmosphere to a height of 150 or more miles. Thus far, the data show that the atmosphere above 60 miles is denser in the Arctic than in temperate latitudes. The reverse was found below 50 miles. Density is also greater in summer than in winter, and during the day than at night. The lowest temperature ever measured in the atmosphere, $^{-}108\,^{\circ}C$, occurred in the summer at 50 miles; winter lows did not reach this extreme and occurred below 30 miles. Upper atmosphere winds were found to be weak and from the east in summer, but very strong and from the west in winter, when a 335-mph velocity was recorded. The import of these facts is not yet entirely clear, but with further study they will someday yield clues helping us better to understand how the world's weather is made.



GENERAL SCIENCE TODAY

By L. CONNELL
Education Department, University of Leeds

and W. S. JAMES
Education Department, University of Bristol

THE movement which led to the establishment of general science as a school subject began, a little before 1920, as a result of the imperfections of the science teaching of the time. The main defects in the science teaching in boys' schools were two. Firstly, the science course was limited to physics and chemistry, and included no biology. Secondly, the physics and chemistry were taught in too academic a way, out of touch with everyday life, and resembled the beginning of a course for specialists rather than an essential part of the general education of every able child. There is no doubt that reform was needed, but the reform movement, through making a sharp distinction between the needs of specialists and non-specialists, took the wrong direction.

It seems obvious that the way to remove the first defect was to urge the inclusion of biology in the school curriculum. But it appears that the reformers, remembering how difficult it had been to persuade headmasters to include any science at all in the curriculum, were convinced that schools would be unwilling to find a place for biology by reducing still further the time given to non-science subjects. So biology had to come in by taking time from the other sciences, and physics and chemistry were pruned to make way for it. There were certainly parts of the physics and chemistry syllabuses which could be cut out without loss; but there was much new material, particularly in current electricity, still outside the syllabuses, which could with advantage have been included instead. There was certainly not too much physics and chemistry—there was, if anything, too little.

Nor did the second defect call for a new subject. Syllabuses and methods of teaching can always be changed, and there is no more difficulty in clearing academic lumber out of a subject if it is called physics than there is if it is called general science. In fact, as everybody knows, physics and chemistry syllabuses have been improved steadily during the

Problems of course content and curriculum sequence in science exist in countries other than ours, as shown by this provocative article. When I first read this in the March 1958 issue of *The School Science Review,* I felt that the sharp definition of issues and the discussion of them by the authors would not only be of interest to readers of *TST,* but would be of real help as we try to resolve problems of our own. We are pleased to reprint the article with kind permission of the authors and of Mr. R. H. Dyball, Editor of *SSR. The School Science Review,* incidentally, is a journal to which all science teachers should have access. Subscriptions ($3.00 per year) should be sent to Mr. S. W. Read, 31 Grosvenor Road, Chichester, Sussex, England. —RHC

last forty years, and if the improvement has not been quick enough the existence of general science, diverting attention away from the real issues, may be partly responsible. As for the way a subject is taught, a new name is not likely to make a teacher teach the expansion of metals or the chemical composition of water in an inspiring way if he did not do so before.

Early Criticisms

The Thomson Report of 1918, though severely critical of the way science was taught, recommended changes very different from those which the general science movement brought about. It wanted *more* science taught, and it suggested that the necessary time should be taken from other subjects. When it talked about the narrow outlook of science teachers it did not mean they had studied too few sciences; it meant they were not sufficiently familiar with "the relations of science to the progress of civilization, its influences on human thought and the history of scientific discovery." Even when it deplored the tendency of teachers to teach only their specialism it did not mean what the general science reformers meant, as it went on to say that teachers should be ". . . encouraged to devote a portion of their time and energies to teaching some subject other than the one in which they are specialists. In particular we agree . . . that the best method of securing co-ordination of the work in mathematics and science is to assign the teaching of mathematics and physics largely to the same teachers." This alliance of physics and mathematics cuts completely across one of the aims of the general science movement, to have physics, chemistry and biology taught by one teacher.

A study of the pamphlet *Science for All* (1920 version) shows the general science movement as a protest against a state of affairs which now no longer exists. The content of the pamphlet was considerably influenced by science masters from public schools, where boys were usually compelled to choose between an intellectual education through Classics and the mere "acquisition of useful knowledge or training" on the Modern or Science side. The science taught in these schools tended to be of such a quality that even the science masters thought ". . . it had better remain a 'special study' for certain Army candidates, and for future chemists, engineers and doctors." (This may still be true in some public schools today, but it is certainly not generally true.) When we recall the many unsatisfactory features of the courses of the time, for example that it was possible to obtain a credit in physics without having studied any magnetism or electricity, we are inclined to agree that ". . . for the non-specialist, general science is better than the limited amount of physics and chemistry that is now customary." The movement is seen also as a protest against early specialization. But when we read in the pamphlet that it is not possible to say whether our pupils are "little chemists or little physicists" we see again that the attack was against something which no longer exists. There can be few schools, if any, nowadays where a boy has to choose between physics and chemistry.

Brymore Secondary Technical School of Agriculture, Bridgwater, England. Mr. St. G. K. Day, Headmaster works with students in chemistry class.

BRITISH INFORMATION SERVICES, N. Y.

We are driven, then, to this conclusion: a new course which was thought more suitable for the non-specialist (if not the specialist) than the conventional courses of forty years ago cannot be assumed to be the best course in today's conditions. The case needs to be re-examined, and the immediate question the supporters of general science must answer is this: *what exactly is wrong with the separate courses of today?*

It is clear that the reforms necessary forty years ago could have been made without the invention of a new subject; there was no need for general science. However, a theoretical justification for general science is sometimes put forward; it is urged that "science is a unity." This mysterious expression may have meaning for some, but it baffles many, including the authors of the first *Teaching of General Science* report, who wrote, "We did, however, find ourselves puzzled by some phrases of which the meaning seems to have been taken for granted by our predecessors. The 'unity of science' was one such phrase; 'breaking down the barriers between the special sciences' was another." When we read in the writing of a well-known exponent of general science that ". . . unless you have the necessary philosophical background, you are liable to get into hopeless confusion when you try to apply the principle (of the unity of science) in detail," we are forced to wonder whether the "unity" cult has any basis whatsoever, and whether there can possibly exist any successful teachers of general science.

The Question of Unity

Significant or meaningless, what effect does the principle of the unity of science have on teaching? Where is this unity found in practice?

It is not found in syllabuses. The subject-matter is always set out with the traditional divisions clear even when they are not labelled. (Sometimes an apology is offered for this arrangement.) The syllabus given in the 1950 *Teaching of General Science* has some interesting features. It was inevitable that the earlier reports would be criticized by chemistry teachers keen on their own subject and out of sympathy with general science. But if the original syllabus was a unity how could more of one of the ingredients be added without upsetting the unity, and what does the report mean when it says that by the addition of more chemistry ". . . a more equitable distribution of time between the branches is obtained"? What constitutes an "equitable distribution"? Equal times for the three branches? But a later statement is even more baffling. "Work on electrolysis and cells has been removed to the Chemistry Section."

As it looks in the syllabus, so it works out in the time-table. Spells of physics, chemistry and biology follow each other. Frequently one is told when visiting schools, "We do general science here —this term we are doing chemistry." The subject could be accurately called physics-with-chemistry-with-biology. The material is much the same as would be taught in restricted courses on the three sciences separately. One has even met a school where general science is taught in which, after a first term devoted to physics, chemistry starts in the second term with a lesson on the differences between physical and chemical change; so, in a subject which was devised to break down the artificial barriers between the branches, one of the branches immediately revolts and proclaims that the barriers are fundamental.

Nor does one find this unity in the textbooks. Titles such as *General Science Physics*, etc., are customary, and even when the three branches of general science are included inside the covers of one book they are usually separated into different sections or chapters.

If the unity of science does not exist in syllabuses or textbooks or in the teaching, one cannot expect to find it in examination papers. Here the "artificial barriers" have to be erected to prevent a candidate who knows no biology from scoring full marks. Indeed, in some G.C.E. examinations, three papers are set for general science, labelled respectively physics, chemistry and biology. In their report *The School Certificate Examination 1932*, the panel of Investigators appointed by the Secondary School Examinations Council wrote, "The Investigators have some reason to believe that with practice the examiners would find it possible so to frame many questions that they demanded a knowledge of the inter-dependence of the different subjects now labelled physics, chemistry, botany, etc., and could not be answered by those who had unduly neglected one in favour of another." This hope has not been realized.

Topics versus Subjects

It is often claimed by advocates of general science that the teacher can make the subject a unity by teaching in "topics" rather than subjects. As all experienced teachers know, the "topic method" can be very useful on occasion, but it can never be a universal approach. A topic like "How our homes are heated" gives the pupils an obvious

motive for their studies. (But a purely intellectual question like "What is the nature of burning?" is no less stimulating to able pupils.) But a good topic does not necessarily link different sciences together. It is the slavish adoption of the "topic method" in an attempt to link separate sciences which makes some general science syllabuses ridiculous. The study of the topic "water," for example, leads to the pupils' studying hydrostatics and the chemical composition of water at about the same time. Now there is no real connection between these two subjects, and there is no reason known to logic or commonsense why they should be studied together; indeed, there is probably good reason why they should not be studied at the same stage of the pupil's development. No chemistry teacher will teach the chemistry of oxygen without referring to respiration, and no physics teacher will teach air pressure without referring to the physiology of breathing, or the lever without referring to bones and muscles and the location of animals. But these are links in the very stuff of science, not artificial links created by a teacher trying to conform to a theory. The good teacher will always stress these links, just as he will show the connections of science with history, geography and other subjects.

A study of children's natural interests in phenomena provides no support for the belief that "science is a unity." It is frequently observed that from the infant years onwards there is no connection between an interest in mechanical things and an interest in animals and plants. Young children often show a great delight in mechanism, much skill in using constructional toys and apparatus, or a taste for the precision associated with the physical sciences, while at the same time exhibiting an indifference to animals or biological phenomena. Others, on the other hand, show an early love of animals and plants and take to nature study very readily, but have little interest in inanimate nature. It does seem that, from the earliest years, children's interests show a marked division corresponding to the fundamental differences between the physical and biological sciences.

Does the unity lie in "scientific method"? Is there one method common to all the sciences and not used outside science? If there were, and if it were an important aim of science teaching to convey an understanding of this method, then the aim would be achieved through one science as well as through three. But surely the desire to have biology in the school curriculum sprang from a recognition that it has something distinctive to contribute to education, something that is lacking in physics and chemistry. In this connection, the Harvard Report *General Education in a Free Society* makes an important point.

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A weather station. Totness Secondary Modern School, Devon, England.

> In going from physics to chemistry, from chemistry to biology, one crosses genuine hierarchical boundaries. The basis of consideration of the natural world changes; different frames of reference are invoked. One either considers different things, or one considers the same things from wholly different standpoints. . . . So it is with almost any aspect of the material world which we care to examine. It is presented to us physically, chemically, or biologically, not merely in different aspects, but on wholly different levels of approach and references. Associated with these basic intellectual differences are wide differences in technical approach. . . . It should be an important aim of general education in science to make this truth clear to students, to give them a clear appreciation of the hierarchy of nature and its reflection in the hierarchy of the sciences.

This passage is both a powerful plea for the inclusion of biology in the curriculum and at the same time an argument against general science.

But the most powerful argument against the "unity of science" and against general science is the existence of so many teachers and scientists who combine a love for one branch of science with a distate for, or at best an indifference towards, another branch. To some this may seem a strange, and even sad, fact but it is one which has been recognized for a long time. The differences between children in their responses to the mechanical and biological worlds become still more firmly established in adults. H. E. Armstrong once said, "Few chemists have any feeling for biology. They simply cannot learn the subject; it does not interest them.

(Continued on page 357)

SCIENCE KITS

In Elementary Science Teaching

By ERWIN F. LANGE and K. E. PAYNE

General Science Department, Portland State College, Oregon

STUDIES of the lives of advanced science students and scientists indicate that many boys and girls contemplating a scientific career exhibit great interest in science very early in life. The intense curiosity of children in things scientific may often be noticeable soon after the child begins elementary school. This interest is manifested by a desire to read a variety of science books and magazines, to experiment, to collect, and to make scientific objects. Again elementary teachers who have developed good science teaching programs report an almost universal interest in science on the part of young children.

The strong desire of children to experiment has been recognized and widely exploited by industry in the development of a large variety of "sets" by which the child can satisfy this urge "to do" by experimenting at home. Among the most popular of these items are the various chemistry sets which have been particularly successful in their appeal to children. These are frequently used as the basis for the development of home laboratories where first-hand experience with a variety of chemicals becomes a reality.

The success of these sets can largely be attributed to the satisfying feeling received by the young experimenter from a successful laboratory experience. Perhaps, a further explanation for the commercial success of these sets is the failure of the elementary school science program to provide these same satisfying experiences. In recent years toy makers have developed functional microscope sets, inexpensive telescopes, radio and motor kits, mechanical devices, and a variety of collection sets to capitalize on the natural scientific curiosity of children. Undoubtedly as industry continues to study the needs and interests of children, a still greater variety of practical scientific toys can be expected.

Considerable progress has been made in recent years in the development of elementary science curricula and in improving the training of teachers in the sciences. Yet problems of activity programs and adequate equipment remain to be solved in numerous schools across the nation. Even though some of the best experiments in elementary science are done with simple, common items which students bring from home or find readily available in the community, it is often desirable to buy some equipment for particular purposes. Generally, elementary teachers have little knowledge as to where or how scientific equipment may be purchased.

Fortunately, classroom teachers are aided in this problem by the availability of a variety of science teaching kits particularly designed for their needs. These might be considered as general science kits and as specialized kits.

Contents

The general science kits usually contain such common items as test tubes, beakers, rubber tubing, simple lenses, magnets, tuning forks, simple electrical equipment, a few chemicals, an alcohol lamp and such other devices as are necessary to perform the experiments described in the prevailing elementary science textbooks. Usually the kits may be purchased with or without a storage cabinet. Experience indicates that it is generally desirable to purchase the cabinet in order to keep the numerous pieces of the kit together. Many of these kits are also equipped with an experiment book or manual which carefully describes many extra experiments.

Among the specialized kits commercially available to elementary classroom teachers are rock and mineral sets, optical kits, weather kits, electrical sets, radio and electronic kits, and even a medical training kit.

Although practically all of these sets and kits contain quality material and can be used successfully to demonstrate many scientific principles, a number of abuses have accompanied their use. Often teachers ill-prepared in science avoid the kits entirely although available in the school, or they

turn them over to a group of students for aimless play. Again, a teacher may use the kit enthusiastically to perform all the experiments possible, even those which should be done at a higher grade level. Consequently, the kit is of little value a year or two later to the teacher who conscientiously tries to use it in her particular class and finds little interest on the part of students in repeating what they have already accomplished.

The writers have noted cases where the school principal was enthusiastic about developing a science program but failed to enthuse the teachers in using the available science kits so that a year or two after being purchased, the kit gradually entered into disuse. Keeping the kit adequately supplied with chemicals, fresh batteries, and other expendable materials often becomes a problem requiring careful attention so that experiments can be performed when needed. Unless care for the kit is specifically assigned to one person there is a danger of the kit becoming useless through loss of numerous pieces or deterioration of critical supplies.

The duplication of the same experiments at different grade levels can partly be overcome by the availability of kits at two levels, a junior kit for the lower grades and a more advanced kit for the upper grades. The use of a specific specialized kit in a particular grade can also help avoid useless duplication. If the school program is carefully planned, the use of the kits available will provide an interesting and rewarding science program.

Assembling School Kits

In spite of the variety of commercial kits available, there is another approach which has considerable merit. Teachers can develop kits to meet their own interests and needs. For instance, in studying a unit of weather at a particular grade level, a teacher or a committee of teachers within the school system can determine which experiments are desirable, buy or make the equipment needed, and in this way assemble functional teaching equipment. A kit for a fourth-grade weather unit might be quite different than a weather kit suitable for a similar unit in the seventh grade. Such kits can be made even more useful by the inclusion of lists of books on weather available in local libraries. If these books cover several different reading levels, all degrees of classroom ability can be challenged and greater student interest can be secured in the project. Teachers have reported the use of science projects to interest children of low ability when other types of materials have failed, which again points to the almost universal interest in science on the part of children.

Useful kits can be developed in subjects such as sound, electricity, chemistry, rocks and minerals, light, and numerous other areas. Science kits may be developed by a single teacher in an isolated school or by groups of teachers in either small or large school systems. In larger school systems a number of identical kits would be assembled and possibly checked out from a central storage place along with other curricular materials. Teachers feeling inadequate for preparing a useful kit should make use of resource personnel such as local high school science teachers, representatives of scientific supply houses, state education departments, science teaching consultants or other available agencies and interested groups.

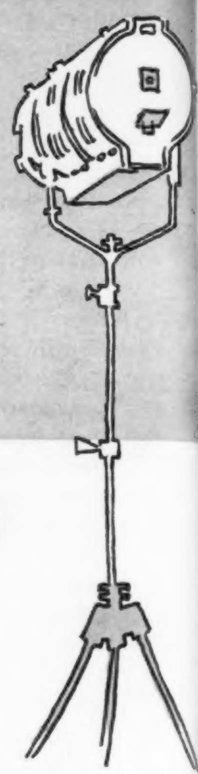
In addition to those mentioned above, a reservoir of talent may be found among local citizens such as those belonging to hobby clubs. Often these people are searching for this kind of outlet to make use of their talents, and to work with students and teachers.

It has been the purpose of this article to point out to elementary school teachers how their science program can be enriched by the use of available science kits and how they might develop kits of their own. Little has been said of the use of supplementary books as these have been discussed from time to time in this periodical. It is the feeling of the writers that much needs yet to be done to make the elementary school science program effective, interesting, and meaningful for children. Rigorous efforts made to improve the elementary science program will have a future effect on supplying the nation with increased numbers of trained scientists now so urgently needed.

Use of Science Kit for intermediate grades.

PORTLAND OREGON PUBLIC SCHOOLS

SPOTLIGHT on RESEARCH



Testing and Evaluation in The Teaching of Science

By WILLIAM B. REINER

Board of Education of the City of New York, Brooklyn

THE purpose of this article is to demonstrate what the classroom teacher of science can learn about testing and evaluation from the findings of research. Investigators in their attempts to determine how well certain science aims and objectives could be attained have utilized many types of appraisal instruments. In studying the advantages of certain teaching methods and devices, they employed various appraisal techniques. Many of their evaluation and testing techniques can be applied in an informal way by the classroom teacher, with great advantage to their pupils and themselves.

Many studies were made of what should be the aims and objectives of science education. Following these came investigations of how certain aspects of these objectives could best be taught. In almost every one of these research studies, tests and various appraisal instruments were used. A great fund of information was accumulated about the various objectives that could be appraised. For example, examinations in the ability to formulate hypotheses, to test hypotheses, to draw conclusions, and to recognize degrees of cause and effect relationship were developed by doctoral degree candidates working under Professor Charles M. Pieper at New York University over a decade ago. Most of the testing techniques developed in these studies can be adopted for informal use by the classroom teacher for testing purposes, for review materials, or as summarizing devices. Teachers can do this by studying the tests, and then writing their own test items to fit the course of study being used for their classes. These items are not at such levels as to deter the classroom teacher from attempting to write them. In a research study, great care must be used to produce test items having high validity, reliability, and difficulty indexes. However, for informal classroom work, teachers can develop excellent test or exercise items by selecting situations that apply to everyday experiences of the pupils, by selecting items related to objectives contained in or germane to their course of study, and by careful editing of the items for clarity and proper vocabulary difficulty levels of their pupils. In short, for informal classroom appraisal of scientific reasoning or similar aims, the teacher need not be concerned about certain technical aspects of validity and reliability. What is important is that the teacher recognize the value of reasoning as an objective, and that he attempt to appraise it in his classroom instruction.

Research indicates that classroom teachers can and should evaluate outcomes and goals other than the memorization of facts. For example, Horton [1] showed quite conclusively that laboratory skills and outcomes in high school chemistry could be carefully defined and appraised. Also Tyler's [2] studies

[1] Horton, Ralph E. "Measurable Outcomes of Individual Laboratory Work in High School Chemistry." *Contributions to Education*, 303: 105. Bureau of Publications, Teachers College, New York. 1928.

[2] Tyler, R. W. "A Test of Skill in Using a Microscope." *Educational Research Bulletin*, 9: 493-496. Ohio State University, Colombus. November 19, 1930.

in biology on the collegiate level, and other studies in physics and general science showed that it was possible to select the steps and procedures basic to laboratory exercises and to rate them with numerical values or by descriptive terms as fair, good, or excellent. Thus, it is possible for a classroom teacher to set up his own scales to appraise how well a class is attaining the objectives of laboratory work stated in the official syllabus, by himself, or by his pupils.

Studies conducted by the Progressive Education Association in connection with the Eight Year Study [3] employed tests of the application of principles of science, the nature of proof, and the interpretation of data. Similar instruments of a less formal type can be written by groups or committees of teachers. Suggestions for the types of questions may be obtained from "Science in General Education" [4] and the 45th and 46th Yearbooks of the National Society for the Study of Education.[5, 6]

Other science outcomes that can be evaluated by teacher-made tests of the informal type are interests, aptitudes, attitudes, problem solving, and applications of understanding. Research studies indicate that these objectives can be appraised with only moderate degrees of reliability and validity. Their testing falls short of the standards of accuracy with which pounds, volts, or feet are measured. The classroom teacher who attempts to evaluate the problem-solving abilities of his pupils is worthy of commendation regardless of how successful he is, if only for his recognition of problem solving as a goal worthy of being taught to his pupils.

Aspects of critical thinking, such as judging which facts or principles support a conclusion, were measured by Dunning.[7] He identified the steps a science teacher could follow to construct his own tests and suggested how the scores obtained from these instruments should be interpreted.

Several research studies [8] have shown that the use of informal techniques such as the observation of pupil behavior, interviews, keeing of anecdotal records, and the examination of pupil logs or diaries are very valuable, particularly with younger pupils, for determining how well they were developing science skills. Some practical suggestions for utilizing several of the above-mentioned techniques are listed below:

1. Laboratory skills and behaviors can be judged on the basis of criteria such as how the pupil arranges his apparatus, works with others, uses apparatus properly, uses reference materials, reaches conclusions, and writes up the report.

2. Individual interviews can be used to find the pupils' interests, adjustment problems, educational or vocational aspirations, attitudes towards scientific problems. This is best done with a prepared check list. Good rapport with the pupil is necessary.

3. Questionnaires and check lists help the teacher to find how the pupil thinks, acts, and feels in certain situations. While the reliabilities are not always high, many valuable insights into pupil behavior can be obtained.

4. Pupil diaries and class journals are useful as self-evaluating devices. They indicate the unfolding of a program and develop an appreciation of the need for planning. They indicate what experiences with projects, hobbies, and books a pupil has had in or out of school.

Selecting Test Varieties

Research workers in the field of test construction and development have found that classroom tests are more effective when the types of questions are varied. For example, a 30-item test entirely of the true-false type is less effective than one having 10 true-false, 10 matching, and 10 completion-type questions. In short, teachers should not limit themselves to one type of test question. Multiple choice items are more difficult to write but they are more reliable. Completion and matching questions have special value for certain types of material. Gerberich [9] made an extensive survey of the many newly developed types of test items which should prove of great value to teachers.

New developments in evaluation include the use of slides, films, television, and sound tapes. This shows an effort on the part of test constructers to

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[3] Progressive Education Association. *Science in General Education.* Prepared by the Committee on the Function of Science in General Education of the Commission on Secondary School Curriculum. D. Appleton-Century Co., New York, 1938.

[4] Ibid. p. 388-439.

[5] *The Measurement of Understanding,* Forty-fifth Yearbook, Part 1 of the National Society for the Study of Education. Chapter 6. University of Chicago Press. 1946.

[6] *Science Education in American Schools,* Forty-sixth Yearbook, Part 1 of the National Society for the Study of Education. Chapter 15. "Evaluation of Outcomes of Instruction in Science at the Secondary Level." University of Chicago Press. 1947.

[7] Dunning, Gordon M. "Evaluation of Critical Thinking." *Science Education,* 38: 191-211. Science Education, Inc., Albany, N. Y. April 1954.

[8] Dunfee, M., and Greenlee, J. "Elementary School Science: *Research, Theory, and Practice.*" p. 53-56. *Association for Supervision and Curriculum Development.* National Education Association, Washington, D. C. 1957.

[9] Gerberich, J. R. "Specimen Objective Test Items: *A Guide to Achievement Test Construction.*" p. 435. Longmans, Green and Company, New York. 1956.

cut down the need for extensive reading by the pupils being examined. The classroom teacher may bring more reality into the testing situation and to find the following suggestions useful in classes where reading abilities are not too well developed or not too dependable.

1. The use of pictures, diagrams, charts and cartoons, for single item, short tests.
2. The use of graphs, tables, "curves" and flow charts.
3. The use of diagram labeling and diagram completion (fill in the missing parts).
4. The use of slides, films, and radio programs for the content base of short tests on the use and care of apparatus.
5. Performance tests in which pupil completes the setting up, joining, wiring, or operation of a device, or completion of a process, as distillation.
6. Identification of objects, tools, and apparatus, such as lenses, electromagnets, condensers, and thermometers of more complex structure or use.
7. The open-book test enables the teacher to ask questions of a searching and comprehensive type, yet saves time in reproducing typed or pictorial materials.
8. Teach-test electrical answer boards afford excellent practice in wiring and a stimulus for teachers and pupils to draw up questions. Pin-ball types of answer games were used by the Navy in World War II.
9. Pupil question boxes or quiz programs are effective in producing rapport.
10. The designing and fashioning of scientific toys, such as the Cartesian Diver, by pupils, is effective.

Scoring and grading tests is so time consuming that many teachers give as few tests as they possibly can. This handicap however can be overcome by having pupils score their neighbors' test papers. Studies have shown that when pupils exchanged papers with each other and scored them in class, with the correct answers written on the blackboard and discussed by the students—the papers were scored satisfactorily and the pupils derived additional instruction. Experience indicates that tests should be discussed and reviewed as soon after they are given as is possible. Short tests should be reviewed in the same period as they are given. Errors corrected immediately result in better learning.

It is possible for teachers to test for objectives other than factual recall, such as reasoning, by utilizing informal techniques fashioned after those used in research studies. Not all evaluation tools need be of the pencil-and-paper type, neither need they be used solely for determining grades. Evaluation techniques of the formal or informal type can be used as part of the teaching process itself.

EDITOR'S NOTE: *This is the second in a continuing series of articles being prepared for this section of* TST *by NSTA's Committee on Research under the chairmanship of Dr. Reiner (see* TST, *September 1958, p. 283). Bill has written, "I would like to urge our readers to submit suggestions, questions, material, and topics or areas for which they would like to have us do a run-down on related research. We hope to keep the show on the road but we want to give what is wanted."*

From Research to Classroom Laboratory...

CULTURING BACTERIA ON MEMBRANE FILTERS

Teacher-Pupil Activity for General Science and Biology

By C. LEROY HEINLEIN
Cincinnati, Ohio, Public Schools

and

EDWIN E. GELDREICH
Robert A. Taft Sanitary Engineering Center

Background

Bacteria are most often found in nature as mixtures of organisms of different kinds. Little information can be obtained with any certainty about the types of bacteria and their activities until they have been separated from the mixture and grown in the presence of bacterial foods or media.

One of the most recent methods used to separate (isolate) and grow (cultivate) bacteria makes use of the membrane filter. This technique applied to the bacteriological analysis of water samples was developed at the Robert A. Taft Sanitary Engineering Center. This method makes it possible to complete a test on water samples in 20 hours as compared to from 48 to 96 hours by the conventional procedure. In this technique, a filter is used to separate or "screen out" bacteria from a fluid such as water.

The membrane filter is made from a thin sheet of cellulose plastic. The filter, about the size of a half dollar, contains over 480 million tiny pores. Each pore is only 0.45 microns in diameter. One micron equals 1/25,000 inch. Since bacteria are one micron or larger in size it is impossible for them to get through the small pores of the filter. Thus the bacteriologist has a rapid method of separating the bacteria from a fluid.

By placing this filter, with the bacteria trapped on its surface, in contact with a suitable food source, each living bacterium is able to grow and multiply into a visible mass called a colony of bacteria. Therefore each colony is the result of growth from a single living organism which was trapped on the membrane filter during filtration.

The identification of the thousands of different kinds of bacteria is a very difficult problem. Bacteria have very few physical differences which can help us tell one from another. These organisms can be divided into only three groups: bacillus, coccus, and spirillum. There are hundreds of kinds in each of these three groups so other means must be used to further separate the different bacteria. Many of these bacteria may be identified by their reactions in special media which contain various organic chemical substances such as carbohydrates, proteins, and alcohols. These tests can only be done with pure cultures of the unknown organism. A pure culture is one that must be free of any other kinds of bacteria which might interefere with its growth reactions in various media. Organisms must be isolated so that when a reaction occurs it is possible to identify the organism producing it.

As an example of the problem of identification of bacteria, the typhoid bacterium (*Salmonella typhosa*) and a common bacterium *Escherichia coli* which is found in soil, water and human feces are both rod-shaped organisms. They look very much alike under the microscope. However if a pure culture of *E. coli* is grown in a lactose sugar medium at body temperature, it will produce visible gas bubbles in 24-48 hours. If a pure culture of the typhoid organism is grown at body temperature in

another tube of lactose sugar medium, it will not produce any visible gas bubbles in periods as long as 30 days. Obviously these two kinds of bacteria are different. In the following laboratory exercises, identification of bacteria will be made using both chemical reactions and physical appearance.

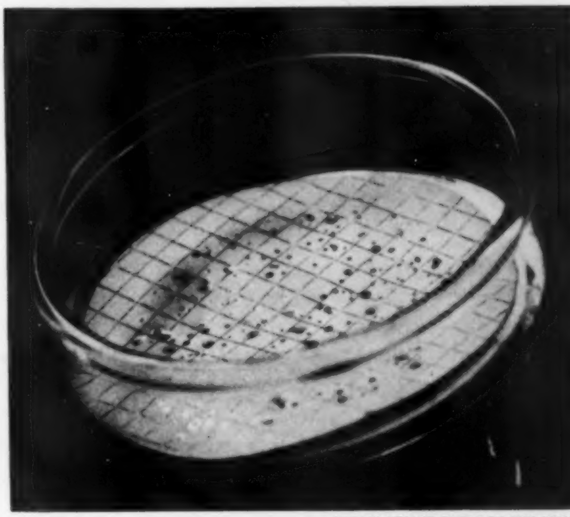
One word of caution, even though bacteria encountered in these experiments are probably harmless, the student should always use the same care in working with these bacteria as he would if they were disease-causing organisms. Wash hands in soap and water after completing the experiments and never put any of this material to the mouth. No food should be eaten in the laboratory. The culturing of bacteria requires careful preparation of sterile nutrients and materials *which should be done by the teacher*. For reliable results, it is recommended that the teacher set up and perform the experiment beforehand to be sure of the sterility of the materials, that the necessary supplies are available and to secure the proper density of the bacterial sample being used.

Statement of problem: The purpose of this experiment is twofold: to familiarize the student with a new basic tool used in microbiology, and to provide the student with an opportunity to use the tool in securing a more rapid, accurate, and less expensive determination of bacterial pollution in water. Formerly 48-96 hours were required to detect bacterial pollution in water; the membrane filter technique reduces this time to 18-20 hours. Water is suggested in this experiment because clean or polluted samples are readily available, it is easy to use, and pioneering applications of the membrane filter were based on the use of water.

Materials

1. *Bacterial sample*

A water sample obtained from a river, lake, polluted well or spring can be used. Choose a quantity of polluted water which gives, after filtration, from 20-60 coliform bacteria on the membrane filter. Thus the colonies will not be too crowded for counting and identification. If raw surface water is used an idea of density can be obtained by using the membrane to filter several samples (3) of 0.01, 1, and 10 ml of polluted water. To obtain a 0.01 dilution take 1 ml of the polluted water and dilute with 99 ml of sterile distilled water. Label this bottle "A." One ml of this mixture is equivalent to 0.01 ml of the sample. One and 10 ml samples of polluted water can be used without the dilution procedure. If sewage is used, filter dilutions of 0.00001, 0.0001, and 0.001 ml. To obtain a dilution of 0.001 of sewage, repeat the dilution procedure outlined for bottle "A" using sewage in place of raw surface water; 0.1 ml of this mixture is equivalent to 0.001 ml of the sewage sample. Take 1 ml of sewage and water mixture just prepared, add 99 ml of sterile distilled water. Label bottle "B." One ml of mixture in bottle "B" is equivalent to 0.0001 ml of the original sewage sample; one-tenth of a millileter of the 0.0001 sample is equivalent to 0.00001. Some idea of the density of coliform bacteria in drinking water from wells, cisterns, springs, or hydrants can be obtained by filtering 10 ml, 50 ml and 100-200 ml of water. Drinking water standards allow only an occasional coliform organism per 100 ml, therefore drinking water can be used as a control in the comparison of organisms in polluted water.



PUBLIC HEALTH PHOTO BY DON MORAN

Membrane ready for counting colonies

2. *Special supplies and equipment* [1]
   a. Filtration equipment
      (1) Field Monitoring Kit
      (2) Sanitarians Kit
   b. Membrane filter media
      (3) Phenol Red Lactose Broth
   c. Colony counting light

3. *Other laboratory materials:*

Pipettes, 1 ml and 10 ml
Graduate, 100 ml
water sample bottles, wide mouth
Dilution bottles, graduated at 99 ml
Incubator—35°C
Hand magnifier, 4X
Gram stain materials:
   a. Gentian Violet Solution
   b. Gram's Iodine Solution
   c. Alcohol 95%
   d. Safranin 1% solution

[1] For sources from which to obtain supplies and equipment, write to Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, attention of authors, or consult references listed.

Nichrome wire needle or loop
Test tubes (several sizes)
Microscopic glass slides
Microscope with oil immersion objective

Procedure

Choice of Membrane Filter Procedures

Two procedures for filtering water samples by the membrane filter are possible—the Field Monitoring Kit and the membrane filter laboratory procedures. Both methods use the membrane filter. The directions for using the Field Monitoring Kit are presented in this experiment because it is a technique involving prepared materials which have been sterilized and made ready for immediate use. The membrane filter laboratory procedure requires more preparation of materials and sterilization of equipment but is more economical in cost when many samples are to be examined each day. Consult the references for the complete procedure.

Sterilization of Materials and Equipment

It is suggested that this should be done by the teacher. A large pressure cooker can be used to sterilize all the necessary glassware, pipettes, sample bottles, and tubes of phenol red lactose broth medium (directions for preparation on the container). The sterilization for all glassware and distilled water should be at 15 pounds pressure for 15 minutes. The tubes of phenol red lactose, used in part "A" of the Follow Up, are to be sterilized for 10 minutes at 10 pounds pressure. Do not exhaust the vacuum after sterilizing the lactose, but let the pressure return to zero by gradual cooling.

Field Monitoring Kit

PUBLIC HEALTH PHOTO BY DON MORAN

Field Monitoring Kit

The Field Monitoring Kit (see photo) used in the experiment consists of a membrane filter in a disposable plastic container that serves both as a filter and incubation unit, a plastic sampling tube, medium ampule and instruction sheet. All materials are sterile and ready for use. A Sanitarians Kit consisting of a syringe, valve and a stainless steel sampling cup will be necessary for a vacuum source. Both single and double kits are available. The Sanitarians Kit can be used repeatedly. This procedure should be demonstrated by the teacher before students attempt to use it.

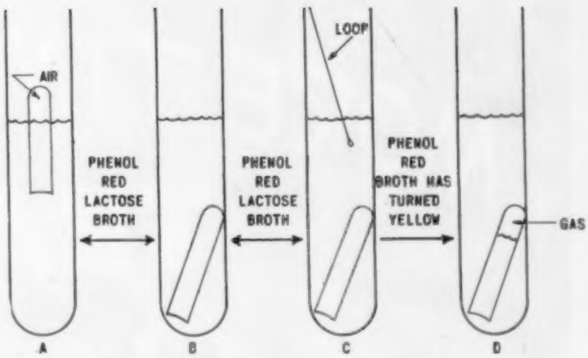
Filtration Procedure:

1. A measured volume of the water sample is placed in the stainless steel sample cup. Proper amount of sample to use will vary with the kind of water being tested. Suggested volumes are stated in Materials-Bacterial Sample.
2. Remove the protective rubber caps and plug the syringe valve and sampling tube into the field monitor. They will only fit in the proper opening of the field monitor.
3. Lower the sample tube into the measured volume of water. Draw back on the syringe plunger to pull the sample through the membrane filter. Several strokes of the syringe may be necessary to draw large volumes through. Invert the syringe, holding the monitor upright (membrane side up) to draw the last few drops through the filter.
4. Remove and discard the plastic sampling tube.
5. Carefully break the narrow tip of the medium ampule at the scored line and insert into the opening on the monitor over the filter surface.
6. Holding the medium ampule firmly in the hand and inserted in the monitor, break the top of the ampule at the scored line. Lift the ampule very slightly to allow medium to flow into the monitor.
7. A partial stroke of the syringe will draw the medium through the filter. Stop pulling on the syringe the instant the last few drops of medium disappear from the filter surface.
8. Replace the protective rubber caps and place each field monitor with membrane filter upside down in the incubator (35°C) for 20-24 hours.
9. After incubation remove cultures from incubator for counting.
10. Pry the field monitor apart. Be careful not to tear the membrane filter which occasionally may stick to the top part of the plastic container. This removal of the top portion of the field monitor makes it easier to see and count the bacterial colonies.

Examining Cultures

Place cultures under the counting light and adjust angle of light for best contrast of the golden-metallic-sheen colonies. Metallic-sheen is best seen by reflected light therefore the incident angle and reflection angle should be as nearly perpendicular to the specimen as possible. If light is not available use a 4x-magnifier and make as accurate a count as possible.

Count all yellow-sheen colonies using the 4x-magnifying lens. These golden-metallic-sheen colonies are coliform bacteria. Since coliforms are normally present in human feces as well as in that of other animals, their presence indicates that the water sample is not fit to drink. The other colonies which are red, pink, or grey, are not coliforms but some of the many hundreds of other kinds of bacteria which might be found in such a sample.



A. BEFORE STERILIZATION
B. AFTER STERILIZATION
C. INOCULATION OF BROTH WITH BACTERIA FROM FILTER
D. TUBE AFTER INOCULATION AND INCUBATION

USING FERMENTATION TO IDENTIFY BACTERIA
Figure 1

Follow Up

A. *How the Coliform Bacteria Are Identified*

When coliform bacteria are grown on a medium containing lactose sugar, the sugar breaks down into other organic chemical substances (aldehydes such as formaldehyde), and these decompose into gases and water. To identify this sugar decomposition use a chemical color test which can identify the presence of the aldehyde compounds. The German bacteriologist, Dr. Endo, made up a lactose medium to which he added the chemicals necessary, to give a golden-metallic-sheen to any bacterial colonies producing aldehyde compounds from this sugar. This medium is called Endo medium in honor of Dr. Endo. A modification of the medium, M-Endo MF, is used in this study and for identification of the coliform bacteria on the membrane filter.

The coliform bacteria will decompose lactose sugar into aldehydes and finally break down the aldehydes into gases and water. This process is fermentation. Another way to identify coliform bacteria is to develop a method for trapping these gas bubbles for visible evidence of gas production. This can be done by inserting a small test tube "upside-down" inside a larger tube of a lactose broth before sterilization of the medium. The resulting heat at sterilization temperatures forces the air out of the small inner test tube (fermentation tube) with replacement by the (liquid) lactose broth. When coliform bacteria are grown in such tubes for 24-48 hours at body temperature, some of the gas evolved by fermentation of the lactose sugar will be trapped in the inner tube giving visible evidence of gas production, see figure 1.

Observing the Fermentation Reaction of Various Bacterial Colony Types Growing on the Membrane Filter

To demonstrate that the coliform bacteria growing on the membrane filter will ferment lactose sugar with gas production, transfer some growth from a golden-sheen colony on the filter into a tube of phenol red lactose broth. Transfer of bacteria is usually done with a nichrome or platinum wire needle or loop held in the end of an insulated holder. To sterilize the wire, heat to a red glow in the flame and cool before transferring the colony to the phenol red lactose broth. Submerge the nichrome wire in the phenol red broth to insure mixing of the bacteria with the broth. After inoculation, incubate for 24-48 hours at 35°C. The coliform bacteria ferments the lactose sugar in the medium resulting in visible gas trapped in the fermentation tube. The phenol red dye will change the medium color from red to yellow indicating an increase in acidity (Figure 1D). By this same method check the reaction of the pink, red and grey colonies growing on the membrane filter. Do they produce gas? Does the phenol red lactose medium change color? Is it more alkaline or acid? (A deeper red color indicates an increased alkalinity.) In picking colonies for this experiment choose well separated ones to obtain pure cultures—not mixtures of different kinds. Why does the bacteriologist work with pure cultures when studying fermentations?

(Continued on page 343)

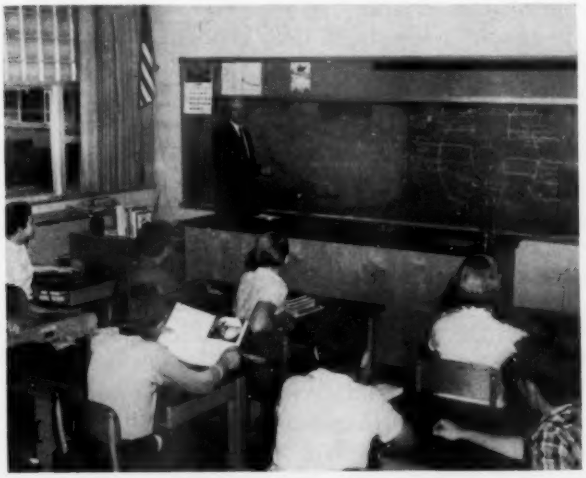
How Is Your Stock of Experts?

By HAROLD E. TANNENBAUM

Science Education, State University Teachers College, New Paltz, New York

THE facilities for teaching science in our schools may be limited—poor—meagre—call them what you will. But it is almost certain that we have not used all the facilities that are available to us. We have not used B-I to the extent and in the various ways that it can be used. B-I is the Business Industry Section of NSTA. It was set up specifically to encourage science teachers to make use of the great resources of American industry. The most important single thing that B-I can offer us is manpower—manpower to supplement our own in the classroom. Here is a reservoir of experts such as no school ever has been able to call on before. There are engineers, chemists, research men of all kinds, technicians, professional men, business men, and government officials all of whom are working in some area of science. These people will take the time out of very busy schedules to come and meet with a class, and will make efforts to visit the schools if the teachers communicate their needs.

B-I stands ready to help whenever possible, but there are even additional resources in the community. The first step is to inventory the community to find which experts are available. The parents of students—both fathers and mothers—offer a primary resource. These people, through both their professions and their avocations, have many interesting materials to bring to the students. And these people will come with an extra, special interest. They would come to help their own children. But they are only one aspect of the resources. Many of the people of the community from the farmers to the miners, from the engineers and the doctors to the plant managers of the factories, will want to share their information and knowledge with the children. The public relations office of the factory or, if it is a small industry, the owner himself, will help supply the needed expert. Government agencies also have their information officers and can arrange for experts to visit the schools and often will have men come from long distances to speak before a class of students.



John H. Gambill of U. S. Steel Applied Research Laboratory teaches general science, grade 9, Monroeville-Pitcairn Jr. High School, Pennsylvania.

With so many people available, the decision as to when to use an expert and what expert to use becomes very important. Two criteria are established for selecting and bringing in an expert. Primarily, we must determine if a man can help the students understand the topic which is being studied. Secondly, we can bring in an expert if he will offer the young people new and wider horizons—a new look at science. If an expert can do both of these things, it is very fortunate. If he can do only one of these things, then we must decide if he is needed. If the expert cannot contribute to the work of the class, or if he cannot open up new vistas to the young people, then his presence in the classroom is not essential.

So, we choose the speaker, either through B-I or directly from the community. What then? Now comes the real work. The teacher must prepare himself, the students, and the invited guest for the coming visit. As far as the teacher's own preparation goes, he needs to be familiar with the expert and his work. Is he a chemist? What kind of special work does he do? What is the problem that the particular guest chemist is trying to solve at present? And what are some of the techniques which he

uses in his work? These things the teachers determine by interviewing the expert and by reading about his work through materials which he can provide. The teacher also needs to find out all he can about the topic which the expert is going to explain. In other words, he cannot wait for the expert to come and just learn along with the children. He must know in advance about the major points which the expert will lecture. Then, the teacher must plan the questions which he will ask. He must ask leading questions which will elicit clear, simple explanations of the problems that the expert is helping the students solve. After all, the teacher must set the stage upon which the expert will give his presentation.

Once the teacher knows about the speaker and his subject, he can prepare the students for the visit. The students, also, need to understand what the expert does, what his special work is, what some of the general tools are which he uses in the solution of his professional or industrial problems. The class must be prepared both with enough basic understandings of the material to be learned and enough specific questions which they wish answered so that the time spent with the expert will be valuable.

Advance Preparations

The third phase of the preparation deals with the speaker. He, too, must be prepared. For the most part, these people have little or no teaching experience and they tend to become too technical for school groups. It is wise for the teacher to spend a considerable amount of time going over the kinds of questions that the students want answered. The visitor will need to know also what technical language he may use and the limitations as to how difficult and complicated his presentation may be. He should understand that he does not have to present the entire range of his speciality. In fact, it is wise to direct the expert as to how broad or specific the topic should be. Finally, he needs to see his role in the teacher's over-all plans. It is well for the expert to know what work has already been done relating to his topic, what the class is doing currently, and what the class plans to do in the future. Then, he can prepare his presentation in a manner to help the class attain its objectives.

After the planning stage, what can we expect from the actual visit? A variety of results no doubt, but there are some things which are likely to happen and some that will not happen. First, what ought we not to expect? We ought not to expect the expert to be a teacher. He can bring the class new and interesting information. He can bring them exhibits and special materials. But he is not likely

to know how to talk to young and inexperienced students. He will need help so that he talks to all the children and not just to the few articulate or particularly able ones.

These, of course, are the "don'ts" of our expert's visit. But what are the "do's?" What can we expect? First, the expert can provide the answers to specific problems which are of concern to the students. He can bring science to life as a usable tool. It is he who uses Ohm's law, or specific gravity, or 0.9 saline solution, or a slide rule, or ionized solutions in his daily work. The students will sense the importance of these things from the experts. What we talk about in theoretical discussions, the experts talk about as materials for the solution of real, vital, daily problems. Next, the expert brings the community uses of science to life. The building marked "County Health Laboratory" stops being a mysterious awesome establishment and becomes an understandable governmental agency as the public health officer talks about its functions and demonstrates some of the work he does. The chemical laboratory in the local factory no longer is the realm of some transmuter of base metals. Now, it becomes a place which does a comprehensible, measurable job.

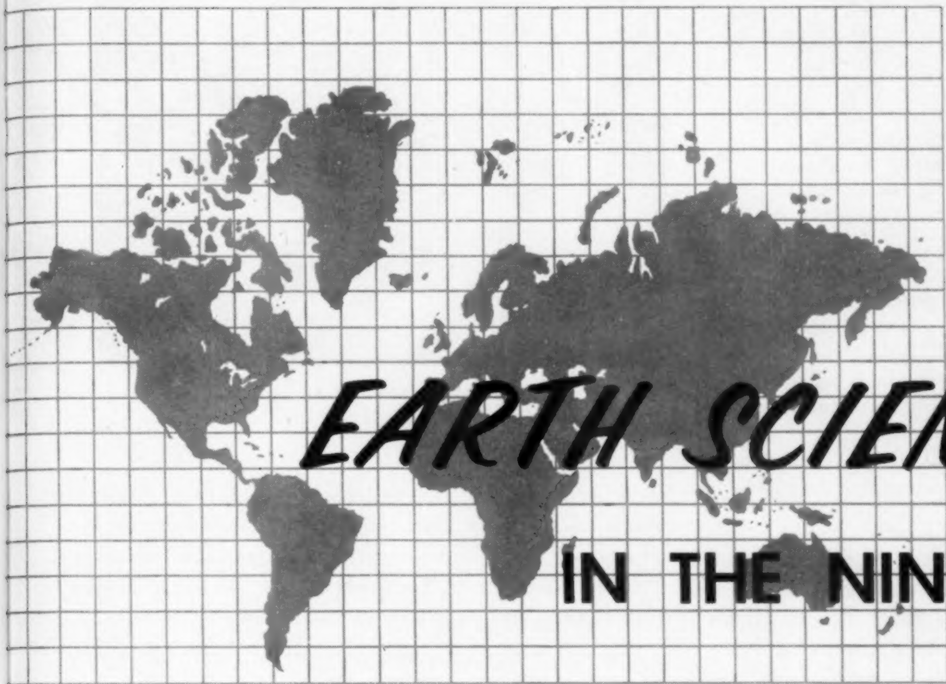
NORTH JERSEY PRESS AND COMMERCIAL PHOTO

"For sleeping, guinea pigs prefer paper bags." (Mr. Robert Wolf of CIBA Pharmaceutical Products, Inc., brings laboratory guinea pigs to children of the class for the blind at Lincoln School, Newark, N. J.)

There is something else which the expert can do. He can help students understand what a scientist is really like. They can learn from the experts about the routines of scientific investigation, about the five hundred failures that go into making one single success, about the human and human humane qualities of scientists, and about the kinds of things which science careers promise and do not promise. This is important both for those students who are planning science careers and for those who are not. Those who are not going into science as a profession need to know and understand the work and the men of science, so that they will provide willingly the necessary support for research and investigation which our society requires and will be able to use the results of this research intelligently. This, too, the expert can bring to the class.

But there is a final accrual from the visit of experts. The experts will learn some of the difficulties which teachers have to overcome in their daily work. The visitors will discover some of the frustrations—as well as some of the joys—of teaching. And they will become aware of and sympathetic with the problems of the schools and the teachers. For the most part, these experts are influential and conscientious citizens. They will not forget their lessons. They will not only come back to be consultants again, they will work for better schools and better science facilities for the schools.

EDITOR'S NOTE: *This article is the first in a series of four to be prepared by Dr. Tannenbaum on aspects of industry-science teaching relations, which are carried on in close cooperation with NSTA's Business-Industry Section. Intended to be informative and helpful both to teachers and B-I educators, the articles will be published in* TST *issues during the 1958-59 school year.*



EARTH SCIENCES IN THE NINTH GRADE

By LOREN T. CALDWELL

Department of Earth Science, Northern Illinois University, DeKalb

THE curriculum committees of most public school systems are taking a critical look at their present science program. The science-learning experiences of the last several years in the first twelve grades have failed to recruit a satisfactory number of students into the sciences as a profession. It is an immediate and urgent problem that school curriculum committees, school administrators, and science teachers determine and correct the weaknesses in our science programs. This feeling of disatisfaction with our science program extends through the elementary schools, the junior high schools, and the senior high schools. Dissatisfaction seems to be most intense in the junior high school and particularly in the ninth grade where general science courses have been most commonly offered. Many school systems are hunting for either a revision of their general science program or a new sequence of learning experiences which might challenge the growing mind of the ninth-grade student in such a way that the student can see the significance of continuing to study in selected fields of the sciences.

Our problem today in the sciences, as they are taught in the public schools, is to let science exhibit its full potential to the student as a force toward good. The beneficent applications of science should be given a clear field to reduce the forces toward war. The public school science teacher must help the teen-age student to see that study of the sciences helps to strengthen the disciplines of the great humanities. This task of the ninth-grade science teacher is made easier when selected earth-science concepts are taught: such as units from the areas of weather, climate, astronomy, geology, and the physical and social aspects of geography. These units should be taught in such a way that they would illustrate the natural applications of laws from physics, chemistry, and biology. By this curricular approach, a study of science can be shown to be one of man's most powerful and noble means for searching out truth and for elevating man's dignity by augmenting his understanding. The misapprehension about the nature and purposes of science as a force toward war may be one of the factors underlying the current shortage of scientists.

Dr. James R. Killian, Jr.,[1] Special Assistant to the President for Science and Technology stated in his Introduction to "New World's of Modern Science," as follows:

> "I do think the evidence is clear that in the secondary schools science teaching has suffered more than teaching in any other field. . . . ."
>
> "Another condition which calls for better public understanding of science is the impact of science on public policy and the impact of public policy on science . . ."
>
> "Clearly, the makers of public policy and the citizens they represent need as never before, to increase their understanding of science. . . ."
>
> "We have urgent need of more scientists . . . . who can build bridges of understanding between the domain of science and the domain of nonscience. We need a growing body of exposition to make science and scientific activity understandable to laymen."

Dr. Killian's statement that we need more scientists who can build bridges of understanding between the domain of science and the domain of non-science serves as a basis for my recommendation that basic concepts from the earth sciences of astronomy, meteorology, conservation, geology, and geography be employed in organizing a year of science for the ninth grade. If we wish to build a bridge between the domain of science and the domain of non-science there is no better way through the scientific method than to find the study units which give natural earth phenomena where laws from physics, chemistry, and biology may be applied, and where man's reaction to natural earth phenomena may be observed. This will make possible a scientific approach to understanding many social behavior patterns on this earth. With such understandings of natural causes for social patterns, the social studies can be helped to become social sciences.

Some assistance should be furnished in this article to those science curriculum committees attempting to make such revisions in their science program. If such a reorganized program is being undertaken for the first twelve grades, this writer suggests that lists of basic concepts desirable for being taught in the secondary school are available from the United States Office of Education. Three studies [2, 3, 4]

Beginning a study of the earth.

have been made in determining those lists of basic principles (concepts) for each of the fields of physical science, biology, and earth sciences. Selections of basic concepts to be taught may be made and related reading materials secured from references.

The earth-science principles made available by curriculum research may be employed by organizing a science curriculum for the ninth grade. From the field of the earth sciences, 332 principles (concepts) of the earth sciences were derived from many public school sources of information. Of these principles, 126 were judged to be related primarily to the area of geology, 75 to the area of physical geography (including weather and climate), 75 to the area of astronomy (including space science), and 56 to the area of the scientific aspects of conservation. Based upon the independent ratings of a jury of nationally known science educators, 117 of these principles (concepts) were rated (13-15) as highly desirable in a scale of rating from 1-15 for use in determining curriculum content in the grades from 7-12 inclusive.

Many bibliographic guides are available [5] to curriculum committees in the development of literature graded to the student, in the organization of information about the basic concepts which have been selected for study. This approach does not prohibit but rather invites the use of teaching methods such as problem, project, or unit organization. This approach to curriculum organization indicates a specific list of purposes for studying science in the ninth grade.

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[1] James R. Killian, Jr. "New World's of Modern Science." Dell Publishing Company, New York, 1956. p. 15.

[2] Caldwell, Loren T. "A Determination of Earth Science Principles Desirable for Inclusion in the Science Program of General Education in the Secondary School." Doctor's Thesis, School of Education, Indiana University, Bloomington, Indiana, 1953. 198 p.

[3] Martin, W. E. "A Determination of Principles of the Biological Sciences of Importance for General Education." Unpublished Doctor's dissertation, University of Michigan, 1944.

[4] Wise, Harold E. "A Determination of the Relative Importance of Principles of Physical Science for General Education." Unpublished Doctor's dissertation, University of Michigan, 1941.

[5] National Research Council, The American Geological Institute. "The Earth For The Layman." Publication 2101, Washington, D. C., 1957. (Reference to literature in the earth sciences separately listed for elementary school, junior high school, senior high school, college, and adult reading.)

There are very few Earth Science textbooks published at present which are designed to furnish a satisfactory course outline and the associated data to meet current needs placed by the public and world situations upon the ninth-grade science program. There is however an abundance of literature[6, 7, 8] written for the ninth-grade student from the concepts of earth science. In most school systems, some outside assistance is needed to help in the organization of this literature for curriculum construction and for use in the ninth grade. Many national science organizations are urging that teams of capable science supervisors be made available through some central agency (such as an Office of Public Instruction) to school systems in need of science curriculum reorganization. It is probable that this assistance should begin with the ninth-grade science program. This would imply that among the science supervisors to be made available to the school systems, a proportionate share of these supervisors should have training and experiences in all of the earth sciences.

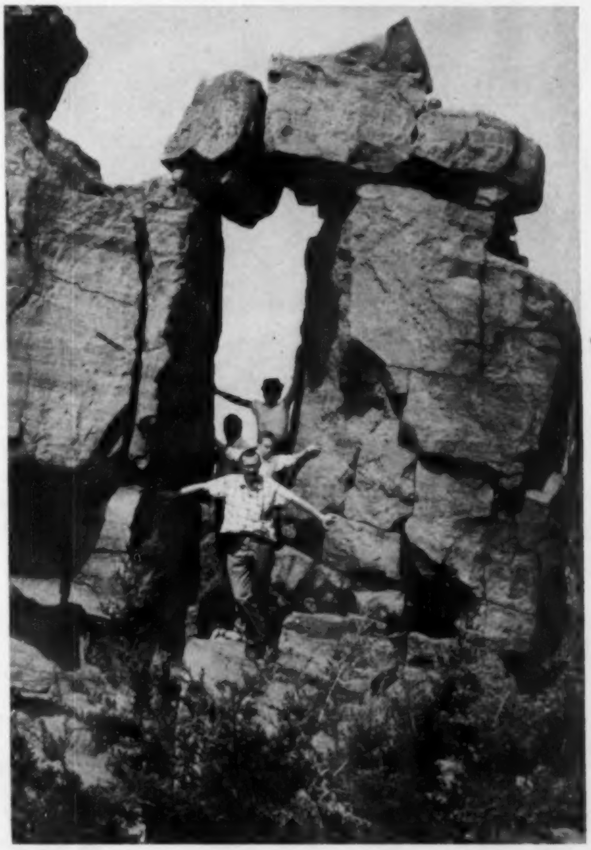
The task of correlating the basic sciences such as physics, chemistry, and biology with the social sciences certainly falls within the areas of the earth sciences. Since the science program of the elementary school is one dealing (largely) with the discovery of common scientific things around us, near and far, and the senior high school science courses deal largely with the specific concepts in separate special sciences on an elective basis, much importance is left to the aims and purposes of the junior high school science program. The task of tying the effects of the basic science world to the social world should be accomplished through the seventh, eight, and ninth grades. Normally much time is spent in the seventh and eighth grades to an awareness of the world distribution of things, conditions, and man. This leaves the ninth-grade student prepared to start that study of the earth sciences where the physical, chemical, and biological worlds are seen as causal factors in the social and economic and political world. This insight can be accomplished through a well-organized science program from the fields of astronomy, weather, climate, conservation, geology, and geography. Dr. Leonard Engel[9] can well be quoted here in this respect.

> ". . . the world that science deals with is a single world, however diverse its different faces appear. There is an intimate connection among the sub-worlds covered by the natural, the biological, and the social sciences. Each has its own laws: but living organisms also obey the laws of chemistry and physics; and man is at once a social phenomena, a biological organism, and an exceedingly intricate bundle of physical and chemical events."

This quotation indicates the need of specifically studying the relations between science and man through natural earth science phenomena.

In the accompanying diagram there has been an attempt to show how earth science principles may be correlated with factual data found in social principles. In this fashion, it is possible that earth science principles may be shown as functional guides for science teachers in building educational bridges between the concepts found in the earth sciences with resultant concepts found in the social principles of the humanities. (See next page.)

Future science teachers observe rock formations.



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[6] Namonwitz and Stone. "Earth Science." D. Van Nostrand Company, Inc., New Jersey 1953.

[7] American Association of Secondary School Administrators. "Conservation Education in American Schools." 29th Yearbook, National Education Association, 1951. (Give references for conservation of natural resources for reading and study from grade three through twelve.)

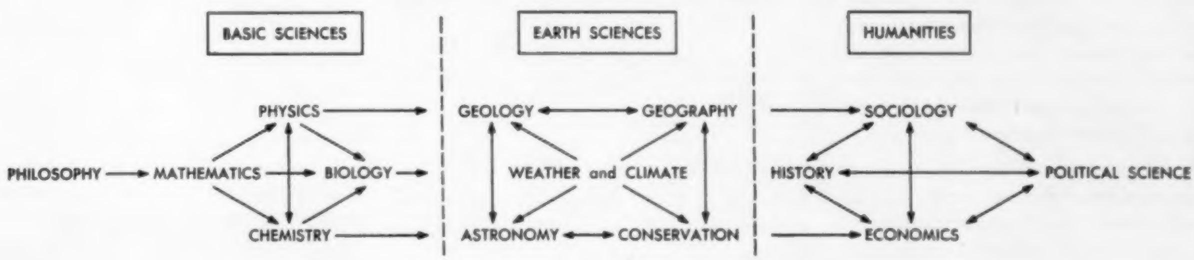
[8] National Council of Geographers. "Journal of Geography." Book Review Sections, *Graded Literature for Geography Bibliographic Lists,* 1953-58.

[9] Engel, Leonard. "New Worlds of Modern Science". Dell Publishing Company, Inc., New York, 1956. p. 19-20.

This bridging of these two fields of our culture may be one of the important services given by earth science principles when they are effectively used as guides to science teaching in the ninth grade of the secondary school curriculum. It is possible that such a curriculum could contribute to the validity of related basic social principles to be studied later. It has become evident to both the science teacher and science student that there are cultural values in relating scientific elements in our culture to their effect-patterns in the significant phases of our culture. When such patterns of relationships have been identified, evaluated, and put into operation in our public school curriculum, society should be in a position to more effectively solve its social, political and economic problems through education. Consequently, it is hoped that the science teacher may be permitted to make a contribution toward a more functional school curriculum with schools allowing abundant curriculum time for this task.

This new task for the science program in the public schools puts a greater burden of training and practice upon the science teacher. It becomes most essential that certification requirements for public school science teachers be adjusted to meet the training requirements of this new and essential task.

Diagram of Correlation Channels Between Scientific Principles, Earth Science Principles, and Social Principles



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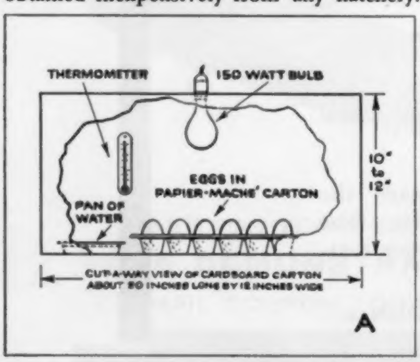
If you have Cycloptics we invite you to try this classroom tested experiment. If not, you may want information about the instrument. We'll be glad to send you our 32 page color brochure. Just write to American Optical Company, Instrument Division, Dept. J95, Buffalo 15, New York and ask for Brochure SB56.

EXPERIMENT

Studying the growth of a living chick embryo

MATERIALS AND PREPARATIONS

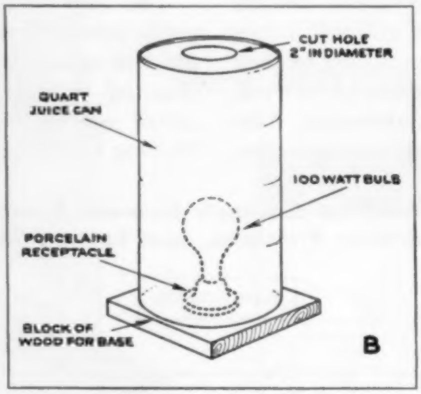
1. Supply of fertilized chicken eggs — preferably 24 hour chick embryos. These can be obtained inexpensively from any hatchery.



2. Incubator: (See diagram). Optimal temperatures are 90° - 110° F. Place small pan of water in incubator for proper humidity (about 60%).

3. Egg Candler: (See diagram B). To candle simply place egg over hole. (Candle in darkened room).

4. Set up Cycloptic Microscope. Melt paraffin and keep hot. Cut "nest" from papier mache' egg carton. Have sharpened steel needle, tweezers, wide mouth medicine dropper, sharp manicure scissors, small brush and clean cover glass ready at hand.



PROCEDURE

1. Select 2 - 4 day old egg. Candle egg to locate position of embryo. This will appear as a shadowy network of blood vessels (area vasculosa) radiating from an indistinct dark spot, which is the embryo.

2. Mark position of embryo on shell with grease pencil . . . do not rotate or roll egg since embryo may shift. Place egg in nest with embryo up.

3. Cut window about size of dime over embryo. Start by carefully picking with needle until small hole is made. Then insert point of manicure scissors into hole and cut (see photo C). Use tweezers to remove pieces of shell. Very carefully puncture egg membrane (immediately under shell) and remove with tweezers. Embryo should now be exposed on top of yolk. Remove excess albumen, if necessary, with medicine dropper.

4. Seal cover glass in following way: with camel hair brush apply melted paraffin to the edges of the window. Gently place cover glass over the window. Seal edges with paraffin. (See photo D).

5. Place egg under Cycloptic Microscope for study. (See photo E). Chick embryo will remain alive for many days and its nervous and circulatory systems can be observed and wing and leg buds can be detected in various stages of embryonic development. Keep egg incubated between observations. Use of sterile technique (wash instruments in 70% alcohol, rinse in sterile .9% saline solution) will keep the embryo alive for a longer period.

OBJECTIVES: This experiment, of course does not attempt to impart a fund of knowledge concerning embryology. However, it lends itself ideally to the achievement of many basic science teaching objectives; i. e., the principles of reproduction and heredity; instrumental and manipulatory skill; appreciations of the work of scientists and the scientific method. And finally, because this experiment has been actually used in classrooms, we know it creates an interest in the broad field of science.

SCIENCE TEACHERS! $25 For Your Experiment

Here's a chance to share your ideas with other teachers. We will pay $25.00 for each experiment involving either laboratory or stereoscopic microscopes accepted by us for future ads like this one. We're looking for unusual experiments suitable for the high school and junior college level. Don't worry about the form, or illustrations, just give us all the pertinent information. In the event of similar experiments the one bearing the earliest post-mark will be used. See your name in print . . . write in now!

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Heinlein-Geldreich . . . from page 331

B. Further information on these organisms growing on the membrane filter can be obtained by preparing stained smears and studying their appearance under the oil immersion objective of a microscope. One of the most important stain procedures ever developed in bacteriology is known as the Gram stain, developed in 1884 by a Danish physician. The procedure divides the bacteria into two groups: those which are stained violet are Gram positive and the others are Gram negative. This information plus observation of the shape can be obtained on the same stained preparation. Coliforms are always Gram negative bacillus type.

Preparation of a Bacterial Smear:

(1) To prepare a slide of bacteria for staining, spread a drop of water on a microscope slide.

(2) Touch a sterile needle to a colony on the membrane filter or to the growth suspension in the phenol red lactose broth tubes. Then touch the needle to the drop of water on the slide. The suspension should just barely be visible to the eye. Too dense a preparation of bacteria (cloudy or chalky looking sediment) is difficult to stain evenly.

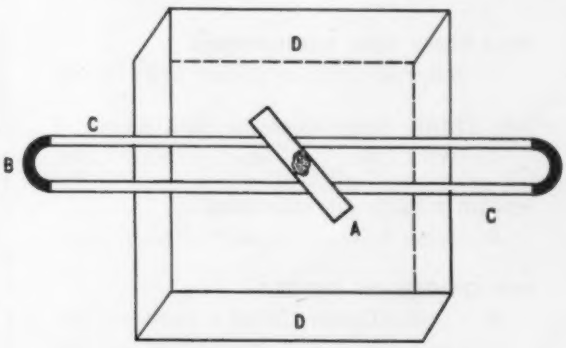
(3) Let the suspension air dry, then pass the slide quickly over a flame 2 or 3 times to heat-fix the bacteria to the glass slide.

Gram Stain Procedure:

1. Place slide on the rack (see figure 2). Stain one minute by completely covering the bacteria side of the slide with gentian violet solution.
2. Wash off excess dye in water. Replace slide on rack.
3. Repeat using Gram's iodine solution. Stain one minute.
4. Wash off excess iodine in water. Replace slide.
5. Decolorize in 95 per cent ethyl alcohol for about 30 seconds by pouring a little alcohol on the slide, agitating it, and washing off the excess alcohol in water. Replace slide on the rack.
6. Next, stain 30 seconds with safranin by completely covering the bacterial film on the glass slide.
7. Use water to wash off the excess safranin, dry, and examine under the oil immersion objective of a microscope. Are the sheen colonies Gram negative? Are they bacillus type? Repeat the demonstration using the red, pink and grey bacteria obtained on the membrane filter. Compare results.

Applications

The membrane filter has many applications in microbiology, nuclear science, general chemistry, pharmaceutical control, oceanography, industrial hygiene, tissue culture and medicine. The filter can be used to examine concentrations of bacteria, yeast, molds, protozoans, etc., from large volumes of water; to determine radioactive particles in waste; to clear microscopic particles from fluids; to collect particles for weight determinations; or to assay airborne hazards like fumes or smokes. At the Robert A. Taft Sanitary Engineering Center it is used as a research tool in the development of more rapid and sensitive indicators of bacterial pollution in water, milk, and foods. In addition, this technique is also employed at this research center in the monitoring of radio-active particulate fallout and other airborne hazards which are associated with air pollution.



A. MICROSCOPIC SLIDE TO BE STAINED
B. RUBBER TUBING
C. GLASS TUBING
D. CONTAINER OR SINK

RACK FOR STAINING
Figure 2

References

"Standard Methods for the Examination of Water, Sewage and Industrial Wastes." 10th Edition. *American Public Health Association*. New York. 1955.

"Biological Warfare." *Life Magazine,* 31:7; 43-49. August 13, 1951.

Gainey, Percy L., and Thomas H. Lord. *"Microbiology of Water and Sewage."* Prentice-Hall, New York. 1952.

Millipore Filter Brochure (On Membrane Filters). Millipore Filter Corp., Watertown, Massachusetts. 1955.

Millipore Filter Brochure (1957 Supplement). Millipore Filter Corp., Watertown, Massachusetts. 1957.

Millipore Filter Brochure (On Field Monitors Used in Water Bacteriology). Millipore Filter Corp., Watertown, Massachusetts. 1956.

SCIENCE TEACHING MATERIALS

BOOK BRIEFS

FRONTIERS OF SCIENCE. Lynne Poole. 169p. $3.25. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y. 1958.

Seventeen brief essays give a preview of scientific developments now under way in many fields. Includes infrared photography, solar energy, atomic wastes, new products from waste materials, digital computers, chemurgy, miniaturization of apparatus, new developments in medicine, and other topics. Interesting and informative reading for high school students.

SCIENCE EXPLORES OUR WORLD: An IGY Report for Students. Hugh Odishaw. 48p. 15¢ per copy. Published by Wesleyan University, Middletown, Conn. Order from American Education Publications, Education Center, Columbus 16, Ohio. 1958.

An authoritative, magazine-type booklet of eighteen chapters; designed for use in general and physical science classes, grades 6-12.

SCIENTIFIC EXPERIMENTS IN CHEMISTRY. Single sheets, 31 in series, 2¢ each. Manufacturing Chemists' Association, Inc., 1625 Eye St., N. W., Washington 6, D. C. 1958.

This is a series of concise, well prepared experiments which should prove highly satisfactory in high school chemistry courses. Very little specialized equipment is required. Fundamental principles of chemistry are covered. Each experiment consists of a "student guide" for use as a set of directions and suggestions for the student and a "teacher information sheet" which explains the mechanics and theory of the experiment in detail.

THE ORIGIN OF SPECIES. Charles Darwin. 479p. 50¢. New American Library of World Literature, Inc., New York 22, N. Y. 1958.

This Mentor edition of the famous classic is published during the centenary year of Darwin and Wallace's joint paper at the Linnaean Society.

THE FOUNDATIONS OF LIFE SCIENCE. Mark Graubard. 627p. $6.50. D. Van Nostrand Company, Inc., Princeton, N. J. 1958.

For college freshmen in general education biology; emphasizes the basic concepts which underlie all branches of biology, with no special division into botany and zoology. Numerous examples are drawn from research to illustrate basic principles. Based upon actual teaching experience.

MEDICINE AND MAN. Ritchie Calder. 247p. 50¢. New American Library of World Literature, Inc., New York 22, N. Y. 1958.

This Mentor book is a popularization of medical history from witch doctor to modern miracles.

GREAT ESSAYS IN SCIENCE. Edited by Martin Gardner. 408p. 35¢. Pocket Books, Inc., 630 Fifth Ave., New York, N. Y.

A collection of thirty outstanding essays of the past in the original words of famous scientists and authors with an introduction to each by the editor.

THE IDENTIFICATION AND EDUCATION OF THE ACADEMICALLY TALENTED STUDENT IN THE AMERICAN SECONDARY SCHOOL. 160p. $1.50. National Education Association, 1201 16th Street, N. W., Washington 6.

Report of a conference on this subject, Dr. James B. Conant, Chairman, Dr. J. Ned Bryan, Director. Deals with problems of motivation, guidance, homogeneous grouping, and special programs for the talented high school student. Offerings for them in science, social studies, languages, and other fields are discussed.

RELATIVITY FOR THE LAYMAN. James A. Coleman. 127p. 50¢. The New American Library of World Literature, Inc., 501 Madison Avenue, New York 22, N. Y. 1958.

This is a Mentor reprint of a 1954 publication. It is a simplified account of the history, theory, and proofs of relativity, written primarily for those with little training in mathematics, physics, or astronomy. A useful book for teacher or student.

PROFESSIONAL READING

"Helping the Gifted." *The American School Board Journal*, Milwaukee, Wisc. 137: 25-27, 63; September 1958. Describes seminar-type programs of four high schools in Massachusetts.

"Chicago Public Schools Television Instruction Experiment in High School Physics." By M. D. Engelhart, E. C. Schwachtgen, and M. M. Nee. *American Journal of Physics*, American Institute of Physics, New York 17, N. Y., 26: 347-349; September 1958. Shows effectiveness of instruction as measured by standardized tests of TV in physics teaching.

"Stimulating the Eureka." By Paul F. Brandwein. *Metropolitan Detroit Science Review*, Detroit, Mich., 19: 16-19; September 1958. The first in a series of four articles dealing with the teaching of bright children.

"The Visiting Scientists Program in Physics." By W. C. Kelly. *Physics Today,* American Institute of Physics, New York 17, N. Y., 11: 21-25; September 1958. An account of the contributions of 75 prominent physicists in college and high school classes.

"Improving Science and Mathematics Instruction." By Lloyd B. Urdal, Henry M. Reiton, Alfred B. Butler, and Gordon E. McCloskey. *The American School Board Journal,* Milwaukee, Wisc., 137: 17-19; August 1958. Describes ways and means to improve science and mathematics instruction in the smaller high school.

"A Science Curriculum to Meet Modern Needs." By Virginia W. Fisher. *The Clearing House,* Fairleigh Dickinson University, Teaneck, N. J., 33: 9-12; September 1958. Describes a suggested science and mathematics curriculum to meet the needs of current programs over a six-year period.

"The Place of Science and Mathematics in the Comprehensive Secondary-School Program." *The Bulletin of the National Association of Secondary-School Principals,* National Education Association, Washington, D. C., 42: 5-12; September 1958. Recommended Curriculum Sequence in Science and Mathematics for Junior and Senior High School Grades.

"An Administrator's Guide to the Elementary School Science Program." 30p. (unpriced) *Associated Public School Systems,* An Affiliate of the Institute of Administrative Research, Teachers College, Columbia University, New York, N. Y. A publication designed to provide an overview which will help administrators in producing elementary school science programs of increased scope and depth. Particularly deals with such problems as developing a climate for elementary science, budget implications, facilities, supplies, and equipment, in-service training, and science resources.

"An Inexpensive Science Library." Compiled by Hilary J. Deason, Director, High School Science Library Program. 38p. 25¢ per copy. 1958. American Association for the Advance of Science and The National Science Foundation, Washington, D. C. A selected list of paperbound science books representing all of the major sciences and mathematics. More than 300 books are listed ranging in price from 35¢ to $4.00 with the majority priced at less than $1.

"The Traveling High School Science Library." 4th Edition. By Hilary J. Deason, Director, High School Science Library Program. 68p. 25¢ per copy. 1958. A listing of all books included in the Traveling High School Science Library Program now in its fourth year, administered by the American Association for the Advancement of Science with financial support from the National Science Foundation, Washington, D. C.

"Recommendations on Undergraduate Curricula in the Biological Sciences." Report of a Conference sponsored by The Committee on Educational Policies. 86p. $1.75 each. Publication 1958, No. 578, National Academy of Sciences, National Research Council, 2101 Constitution Ave., N. W., Washington 25, D. C. Summarizes the results of the conference which undertook to re-examine undergraduate teaching programs.

"The Planned Program and Problem Solving in Elementary Science." By Grace C. Maddux. *Metropolitan Detroit Science Review,* Detroit, Mich., 19: 24-25, 50; September 1958. A plea for a planned program, showing that such a program need not exclude incidental and spontaneous science learnings.

APPARATUS AND EQUIPMENT

Plant Science Kit. For use in the lower grades. Contains materials for growing plants from seeds so that the roots are visible. Directions for twenty experiments. $1. The Library of Science, 59 Fourth Ave., New York 3, N. Y.

Satellite Finder. A device that can be used by high school students to locate the constellation through which a satellite is expected to pass. $1. New World Products, 13273 Ventura Blvd., North Hollywood, California.

The Planetariat: A Two-Dimensional Planetarium. A device for home or classroom student use. Demonstrates the motions of the Solar System against the background of the fixed stars. Planetariat consists of four main divisions—solar system positioner, star charts, horizon indicators, and manual, as a complete assembly but parts may be purchased separately. Excellent for small groups use and individual use. Set. $12.50. Individual parts and larger sized solar system positioners priced on request. Armistead and Goodman, Inc., P.O. Box 66, St. Louis 3, Mo.

Satellite Pathfinder. A device to calculate when any man-made earth satellite will appear over any spot in the Northern Hemisphere. $1.95. The Library of Science, 59 Fourth Ave., New York 3.

AUDIO-VISUAL AIDS

Work of the Blood. Suitable for high school biology and college biology and anatomy studies. Describes blood composition and components. Shows preparation and staining of slides, counting blood cells, and blood cell production in the bone. Network of arteries, arterioles, capillaries, venules, and veins are briefly described; also action of white cells ingesting bacteria; and test methods for typing and Rh factors. 18 min. Color $125, B&W $62.50. 1957. Encyclopaedia Britannica Films, 1150 Wilmette Ave., Wilmette, Ill.

Earthquakes and Volcanoes. Recommended for upper elementary and junior high science, but usable at higher levels. Shows causes of earthquakes and volcanic eruptions. Models and diagrams used to show formation of earth and earth crust movements. Includes newsreel pictures of eruption of Vesuvius and Mt. Kilauea and the 1952 earthquake at Tehachapi, California. 14 min. Color $125, B&W $62.50. 1958. Film Associates of California, 10521 Santa Monica Blvd., Los Angeles 25, California.

Understanding the Physical World Through Measurement. For physics classes in high school, or general physics college students who plan to enter physics or engineering studies. In the form of lecture demonstrations; emphasis on the significance of physical measurements. 33 min. Color. Sale, $14.43 and also available on loan. National Bureau of Standards, U. S. Department of Commerce, Washington 25, D. C.

Trees. Illustrates how to identify common trees by study of shape, bark, leaves, and fruit; differences between deciduous and evergreen trees, and regional in tree populations. Recommended for science in the intermediate grades. 11 min. Color $100, B&W $55. 1958. Coronet Instructional Films, Coronet Building, Chicago 1, Ill.

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Shown here (by popular demand!) is your NSTA headquarters staff. Seated: Marilyn Suthard, Secretary to Mr. Carleton; Robert H. Carleton, Executive Secretary; Kent Godwin, Administative Assistant. Standing: Margaret J. McKibben, Assistant Executive Secretary for Professional Relations; Frances J. Laner, Director of Publications; Marcia Felter, Secretary to Miss McKibben; Judy Kuhn, Administative Clerk; Gail V. Leggett, Membership Clerk; Glenn E. Warneking, Assistant Executive Secretary for Membership Services; Edith M. Nicholas, Membership Secretary; Alicia G. McKelvie, Editorial Secretary to Miss Laner; Thelma Ruth Wargo, Secretary to Mr. Warneking; Noli Evangelista, Mail and Stock Clerk.

NSTA Activities

Election of Officers

NSTA members are urged to suggest and submit names of nominees for positions to be filled in the 1959-spring elections. These positions include: the national offices of president-elect and treasurer and the regional offices of directors for Regions I, III, V, and VII. The candidates for all these offices are both nominated and elected by the membership at large.

Since the Elections Committee will meet on November 21, the names of nominees should be in the mail by November 10. The names should be sent to Brother I. Leo, F.S.C., currently chairman of the Elections Committee, at St. Mary's College, Winona, Minnesota.

Other members of the Elections Committee are: Muriel Beuschlein, Chicago, Illinois; Charlotte Grant, Oak Park, Illinois; Virgil Heniser, Indianapolis, Indiana; Nelson Lowry, Arlington Heights, Illinois; Mary Jane McDonald, Fond du Lac, Wisconsin; and Alton Yarian, Lakewood, Ohio.

In submitting names, please also send the following information: present position, address, NSTA position for which recommended, and brief summary of nominee's professional interests, activities, and education.

Following the submission of a candidate's name, the nominee is sent prompt notice as recognition of his selection and worth in the position to be filled. The submission of names by the membership at large is encouraged so that officers selected have the confidence of the voters. As a consequence, it is felt NSTA may continue to operate successfully with the support of its members and their chosen candidates.

AAAS Meeting

For the tenth successive year, science teaching societies affiliated with the American Association for the Advancement of Science will hold a joint meeting December 26-30 in conjunction with the annual meeting of the AAAS. The meeting this year will be in Washington, D. C., with headquarters for all science teaching societies and all sessions at the Shoreham Hotel. (For hotel reservations, write to the AAAS, Housing Bureau, 1616 K Street, N. W., Washington 6, D. C. The sooner you write the better; arrange to share a room with one or more others if possible.)

Individual sessions will be conducted by the American Nature Study Society, the National Association of Biology Teachers, the National Association for Research in Science Teaching, and the National Science Teachers Association. Section Q of the AAAS will also join in sponsoring some sessions. NSTA sessions will include "Here's How I Do It" demonstrations as well as panels and symposia for junior and senior high school levels. Other special sessions are planned for elementary levels.

All of the societies will join in sponsoring the Annual Mixer. There will be tours to research laboratories in the Washington area and a general session which will report on "IGY after 18 months of activity." The annual NABT-ANSS field trip is scheduled for Tuesday morning, December 30. Printed copies of the program will be mailed in advance to all members of the participating associations (to NSTA members east of the Mississippi River only; available to others on request). It is important to make advance reservations for the mixer, the field trip, the tours to laboratories, the annual NABT Luncheon, and the ANSS dinner. Information and necessary forms will be included in the program.

Convention Notes

Watch for additional information on the Atlantic City convention (March 31-April 4) in the November issue of *TST*. Right now, those who would like to have a leadership role in discussion groups should send their names, positions, and institutional connections to the Executive Secretary.

There will also be several program spots for "Here's How I Do It" presentations in elementary science, junior high school science, and biology, chemistry, and physics. *These are strictly limited to 15 minutes.* Those who have presentations to be considered should write to the Executive Secretary and give descriptions of what they propose to do so that the planning committee can build an effective and varied program.

Two new variations in the registration plan will be tried this year. First of all, registration will be required for admission to all sessions. Secondly, a daily registration fee will be offered to accommodate those who can attend only one or two days or certain sessions. The daily fee will be $1.00; registration for the full convention period (or 3 to 5 days) will be $3.00. Catholic science teachers who will be attending the convention of the National Catholic Educational Association during March 31-April 3 have been invited to take advantage of the daily registration plan.

FSA Activities

Publications

The 1958-59 (5th) edition of our career information and guidance bibliography titled *Encouraging Future Scientists: Keys to Careers,* was distributed recently to 25,000 NSTA members and other key teachers in Packet 46. This revision of publication (originally done by Dr. John H. Woodburn five years ago) was prepared under the supervision of Dr. Orval L. Ulry, University of Maryland, College Park. Single copies are available to science teachers and counselors free of charge; quantity lots, 10¢ per copy. Preparation, publication, and distribution of *Keys to Careers* constitutes one of the major projects among a total of 13 which comprises the FSAF program for 1958-59.

Registry of U. S. Science Teachers

For the third successive year, some FSAF funds are being used to establish a registry of science teachers in U. S. junior and senior high schools. The project has been bolstered and expanded this year in two ways:

1. Adequate financing has been assured by a supporting grant of $11,900 from the National Science Foundation to NSTA;
2. The National Council of Teachers of Mathematics (NEA) is cooperating and and the registry will include mathematics teachers in grades 7-12.

Names of all the teachers, their teaching assignments, and other pertinent data will be entered on coded punchcards. A list of 100,000 names is expected to be ready for use by December 1. Report forms have been sent to about 28,000 high school principals.

Readers of *TST* can help promote the registry project by checking to make sure that their principals have filled in the forms and mailed them back to NSTA headquarters. It is important that all science and mathematics teachers, regardless of whether they are members of NSTA or NCTM, be reported *on these forms* so that the registry will be as complete as possible. It will undoubtedly be used for many important mailings over and beyond those sent to members of the two associations.

Last year, through the registry a total of approximately 35,000 science teachers were reached. It was used on at least some 50 occasions for purposes of sending out announcements of summer opportunities for science teachers, advance information on science films via TV, scholarships and award programs for students, and for other professional purposes. The list is not available for commercial advertising. Groups who do make use of the list pay for this service at minimum rates necessary to cover the costs of the operation. Educational groups wishing to make use of the registry should contact NCTM for mathematics name lists and NSTA for science name lists.

Conference Reports

Just off the press is a combined report on FSAF conferences held during the summer of 1957 at San Jose State College, California, the University of Maryland, and Swarthmore College in Pennsylvania. The three conferences were sponsored by Crown Zellerbach Foundation, West Virginia Pulp and Paper Company, and Scott Paper Company Foundation, respectively. The publication contains three sections dealing with "Teacher Demonstrations in Chemistry", "The Science Teacher as Career Counselor," and "Teaching Critical Thinking Through Chemistry."

Copies have been sent to life and sustaining members and to library subscribers as part of their special membership services. It is available to others at $1.00 per copy from NSTA headquarters.

Help Wanted

NSTA is now in the process of reporting program plans and accomplishments to all FSAF sponsors who have made financial contributions during the calendar year 1958. Experience has shown that many contributors respond during the closing months of each calendar year. These and other companies who have not joined the roster of sponsors for this year are being given an opportunity and invitation to do so. Teachers and others who may know potential sponsors can assist by encouraging companies in their localities to join in support of this nationwide effort to improve and strengthen the teaching of science in the schools. Copies of *Destiny in Science,* which describes the Foundation and its work, are still available and will be sent free on request.

NSTA CALENDAR

As a regular feature of *The Science Teacher*, the calendar will list meetings or events of interest to science teachers which are national or regional in scope. Send your dates to *TST's* calendar editor. Space limitations prevent listings of state and local meetings.

October 17-18, 1958: NSTA Southeast Regional Meeting, Nashville, Tennessee

October 17-18, 1958: NSTA Southwest Regional Meeting, Pasadena, California

October 26-28, 1958: SAMA Laboratory Apparatus and Optical Sections of Chicago, Midyear Meeting at Rye, New York

November 7-8, 1958: Association for the Education of Teachers in Science at Teachers College, Columbia University, New York City

November 9-15, 1958: American Education Week

November 27-29, 1958: 58th Convention, Central Association of Science and Mathematics Teachers, Indianapolis, Indiana

December 27-30, 1958: NSTA Annual Winter Meeting with science teaching societies affiliated with the American Association for the Advancement of Science, Washington, D. C.

December 28-30, 1958: 18th Christmas meeting of the National Council of Teachers of Mathematics, New York City

February 19-21, 1959: National Association for Research in Science Teaching, Atlantic City, New Jersey

February 21, 1959: Council for Elementary Science International (CESI), Atlantic City, New Jersey

February 28-March 1, 1959: CESI, Cincinnati, Ohio

April 3-4, 1959: CESI, St. Louis, Missouri

March 31-April 3, 1959: Annual Convention, National Catholic Educational Association, Atlantic City, New Jersey

March 31-April 4, 1959: NSTA Seventh National Convention, Atlantic City, New Jersey

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The National Geographic Magazine is collecting material about IGY activities. Did your classes or your community participate in some IGY projects? Can you recall any stories of students showing particular interest in IGY? Are IGY findings affecting your courses in any way? If so, please send details by November 15 to Peter White, National Geographic Society, Washington 6, D. C.

CONNELL-JAMES . . . from page 319

This mental peculiarity is very curious." This seems to apply even more strongly to physicists, and, of course, the reverse also is true. One meets biologists who are not merely ignorant of physics but quite lacking in any feeling for it. Physicists who have taught biology will remember the entertainment they got from a popular Sixth Form biology textbook (in its second edition, and seventh printing), whose authors, feeling the need to explain the term "refractive index," gave the following definition: ". . . when rays of light pass through a solid or a fluid into a gas, or through some solids into some liquids or vice-versa, they are bent to an extent which varies with the substances involved. The angle which the rays form with the surface through which they pass is known as the refractive index of the subject." This definition is not merely wrong. It betrays an utter lack of feeling for the outlook of physics. If a boy in a physics class offered it, his teacher would despair.

Combining Specialties

Experience suggests that the physicist's ignorance of biology and the biologist's ignorance of physics are not results of education, but are more fundamental. It is not merely that the average biologist is ignorant of the facts of physics but could learn them by reading; the truth seems to be that he has no aptitude for the subject. As Armstrong would say: "He simply cannot learn the subject." There are physicists who have conscientiously tried, by attending courses, to overcome their ignorance of biology, but have had no success; the subject has left them cold. But these same physicists may well have a passionate interest in music or literature or some other non-science subject. In any group of science graduates it is rare to find any who are keen to teach both biology and physical science, even when they have studied both at the university and passed examinations.

But this narrowness is not regrettable; it is perhaps even fortunate. A serious interest in, say, mathematics and physics will occupy a great deal of a man's time. Should he spend a large amount of the remaining time on another science or on a non-science subject? Surely it is better to pursue interests in common with non-scientists. We are often told that there is a gulf between scientists and others. A man who tries to be a physicist, a chemist and a biologist will have little time to bridge the gulf.

The fact that nearly all science teachers prefer to teach either physical or biological science, but not both, should by now be accepted as axiomatic. Any educational policy which pretends otherwise will not succeed. In the original *Teaching of General Science*, Part I, this seemed to be accepted: ". . . unless a teacher deals with material in which he is interested, in a manner which is interesting to him, he is most unlikely to interest his pupils in it." But in Part II there occurs this extraordinary statement: ". . . the man who knows his subject best is not always the best teacher of it, and boys are as willing to learn with a man who admits his limitations as they are from one who always speaks with authority." It is tragic that science teachers should ever have countenanced this declaration. The physicist teaching physics will certainly have limitations and will be glad to repair them publicly when he is asked a searching question; the occasion will be a valuable lesson to his pupils. But the same physicist dutifully but reluctantly teaching biology may well be ignorant of facts the children in the next form are supposed to know, and the constant exposure of his limitations will not inspire confidence, nor will it give his pupils exciting glimpses of the pleasures ahead.

The time allotted to general science, because it is looked upon as one subject and not three, is so limited that an adequate amount of practical work, the very life-blood of any science course, is not possible. "There is no time for practical work" is now the common cry of teachers of general science.

Manchester Grammar School. Students working in building laboratory which is part of Science Block. (In England buildings are separated into blocks concerned with the particular area of study.)

BRITISH INFORMATION SERVICES, N. Y.

Can we be satisfied with a grammar school course in science in which pupils rarely handle the simple pieces of scientific appartus or do experiments themselves? In some schools the opportunity of experimenting is reduced still further because the different sciences are not taught in their own laboratories. The common-sense view is that physics should be taught in the physics laboratory, chemistry in the chemistry laboratory and biology in the biology laboratory. But the principle that general science is a unity denies this, proclaiming instead an undivided subject-matter which may very well be taught in one room throughout the year. Evidently if pupils received part of their instruction in each of the three laboratories this would destroy the illusion. So we find physics being taught in the chemistry laboratory, perhaps by a biologist, and all the other combinations possible on this theme. A few teachers, it is true, make an effort to maintain some practical work in their classes by carrying apparatus and chemicals from laboratory to laboratory, and waste much time and effort in doing so; others, however, adopt the simpler course of giving up practical work almost completely.

Restoring Quality and Interest

It was certainly not the intention of those who pioneered general science that laboratory work should be almost eliminated or that the spirit of heurism should perish. But that is how science teaching has developed in many of the schools which have succumbed to the temptations of the easy option, "general science." One finds so frequently general science teaching which is dreary, lacking in purpose and divorced from its experimental setting—bad teaching carried out in bad conditions. We need a new Armstrong to restore to this science teaching those qualities which it has lost as sound laboratory work has gradually disappeared from the general science courses.

Probably the most serious defect of general science when it is taken all the way up to Ordinary level is that it fails to provide pupils with the necessary foundations for their Sixth Form studies. For example, new arrivals in the science Sixth Form know hardly any chemistry, not having progressed far beyond an elementary study of the atmosphere, water and carbon dioxide. These victims of general science know nothing of equivalent or atomic weights, of chemical equations or the main bulk of Ordinary level chemistry. In less than two years they will be faced with their Advanced and Scholarship level papers. What should be an educative process must necessarily become a cram course designed to get the under-privileged candidates through the examination at all costs, and once more the practical work is neglected.

It is impossible to reconcile this practice with the universities' demand for a broader Sixth Form curriculum. General science may well prove to be the main cause of the alleged "illiteracy" among science students entering the universities. There can be little doubt that Sixth Form courses should be broadened in scope and content, but this is not feasible for those who have studied only general science. Only when students enter the Sixth Form with their full science subjects at Ordinary level can one begin to think of introducing arts subjects into their studies.

Has the general science movement achieved its original aims? It has, it is true, resulted in some pupils studying a small amount of biology, but the biology presented to them by most non-biologists is not worth study. It has not given science teachers a new, broad outlook. On the whole, the subject is less inspiring than the separate sciences, because parts of it are taught without enthusiasm. One of the main reasons given by many science graduates for not wanting to teach is that school science, before the Sixth Form, is so elementary. It seems likely that general science has contributed to this view. Any subject taught by a person with no great knowledge of it and no great enthusiasm for it must be elementary, and can never be inspiring for the pupils or satisfying to the teacher.

Conclusion

At this time of national need for more scientists and technicians the glaring inadequacies of general science are especially serious. Some pupils give up all ideas of taking advanced science courses when they realize the disadvantages under which they labour, and many schools, aware of the difficulty, fail to offer such courses at all. It is not only Sixth Formers who suffer; those who wish to enter colleges of technology or certain scientific professions at the age of sixteen often find that general science has not given them the required qualification. Surely a subject which at this time prevents able pupils from embarking on scientific careers stands self-condemned.

Schools must, sooner or later, respond to the demands made on them by a changing world. They cannot indefinitely ignore the larger issues and continue educating their pupils for life in an age

which is already past. We have left behind the conditions of the nineteen-twenties, when a contracting industry and a depressed economy had more than enough scientists for their needs. Things are different now and the newer discoveries in physical science guarantee for a long time to come a sustained and increasing demand for scientifically trained people. But so far too few grammar schools have responded to the urgent demands being made on them or even shown much awareness of their new responsibilities. The time has come for the three major sciences to claim their just places in the school time-table, each taught from the outset by specialists and with adequate time for laboratory work. It may be, indeed, that a subject physics-with-chemistry-with-biology (perhaps still called for the sake of brevity "general science") will continue to find a place in the Ordinary level examination for those of limited ability; but certainly all able children in our grammar schools should take at least two sciences to Ordinary level even if they drop the third science somewhat earlier. But in any such re-organized system of science teaching, general science as it now exists, with all its disadvantages and frustrations, can have no place. An improvement in the standards of school science teaching is now over-due and is a requirement for the continued existence of this country as a leading scientific and industrial nation. As a first step in this direction general science as a subject in the grammar school curriculum should be replaced by separate courses in the three main sciences.

May I introduce myself? I am *Hector,* also a staff member of NSTA, but I was away when the staff picture was made.

From time to time, I plan to bring you news of NSTA publications. Below are two new ones just off the press:

1. ***Experiments with Radioactivity.*** Prepared by committees of Connecticut science teachers under the chairmanship of Robert W. Shackleton in a Civil Defense Education project headed by Dr. Arthur Goldberg of the Connecticut State Department of Education; 15 experiments, list of suppliers of radioisotopes, bibliography. 24p. 50 cents.
2. ***Let's Build Quality into Our Science Tests.*** By Clarence H. Nelson. Written in cooperation with NSTA's Committee on Evaluation; gives philosophy of tests, principles of test writing, examples of tests for use in teaching and evaluating, bibliography. 24p. $1.00.

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